ELSEVIER

Palaeogeography, Palaeoclimatology, Palaeoecology 147 (1999) 257–281

PALAEO

Predominance of arid climates indicated by mammals in the pampas of Argentina during the Late Pleistocene and Holocene

Eduardo P. Tonni [a,*], Alberto L. Cione [a], Aníbal J. Figini [b]

[a] *Departamento Científico, Paleontología Vertebrados, Facultad de Ciencias Naturales y Museo, 1900 La Plata, Argentina*
[b] *LATYR, Facultad de Ciencias Naturales y Museo, 1900 La Plata, Argentina*

Received 15 April 1997; accepted 24 August 1998

Abstract

South American climates during the Pleistocene and Holocene are poorly known, especially in the lowlands east of the Andean ranges. However, there is relatively good biostratigraphic and climatic information for the late Lujanian and Platan local ages (latest Pleistocene to Holocene) of the Pampas region. Most of the climatic data from the Pampean area are based on land mammal assemblages, pollen records, and geology. Contrasting with North American faunal associations, there are many non-analogue assemblages in the Holocene of the Pampean area. The climate was arid and relatively cold during most of the early Lujanian. However, several relatively wet and warm events are suggested by the presence of subtropical mammals and evidence of tchernozoid paleosoils. The late Lujanian is well represented by the fossiliferous sediments of the La Chumbiada and Guerrero members of the Luján Formation (ca. 30,000 and 21,000–13,000 yr B.P., respectively), cropping out in stream valleys in the Buenos Aires Province. Mammal assemblages suggest a change from a temperate to a cool climate from the La Chumbiada Member to the Guerrero Member, the latter representing the last glacial maximum. The lower portion of the eolian La Postrera Formation has been dated at 11,000–8000 yr B.P. This section was deposited on basin divides under dry and cool conditions. The mammal association was similar to that of the Gueffero Member and includes the last megaherbivore mammals in South America (e.g. *Megatherium americanum*). Mammals occurring in Platan beds usually indicate dry but not cool conditions. Warm and probably wetter conditions were detected in continental beds deposited synchronously with a mid-Holocene marginal marine ingression (ca. 7000–6000 yr B.P.). A Holocene non-analogue assemblage of subtropical mammals and dry/cold indicators occurred at latitude 38°30′S at ca. 2000 yr B.P. Subtropical mammals that require wetter conditions have been migrating southwards in the Pampean region since 1500–1000 yr B.P. Eolian sediments in the La Postrera Formation dated ca. 440 yr B.P. yielded an arid to semiarid mammal assemblage which could relate to the Little Ice Age period. Remarkably, most of the present-day manual biocenoses and climatic conditions in the Pampas seem to have been recently established. Paleogeographic maps for the last glacial maximum and the mid-Holocene are also provided. © 1999 Elsevier Science B.V. All rights reserved.

Keywords: South America; Argentina; Quaternary; climate; mammals

---

[*] Corresponding author. E-mail: eptonni@museo.fcnym.unlp.edu.ar

0031-0182/99/$ – see front matter © 1999 Elsevier Science B.V. All rights reserved.

PII: S0031-0182(98)00140-0

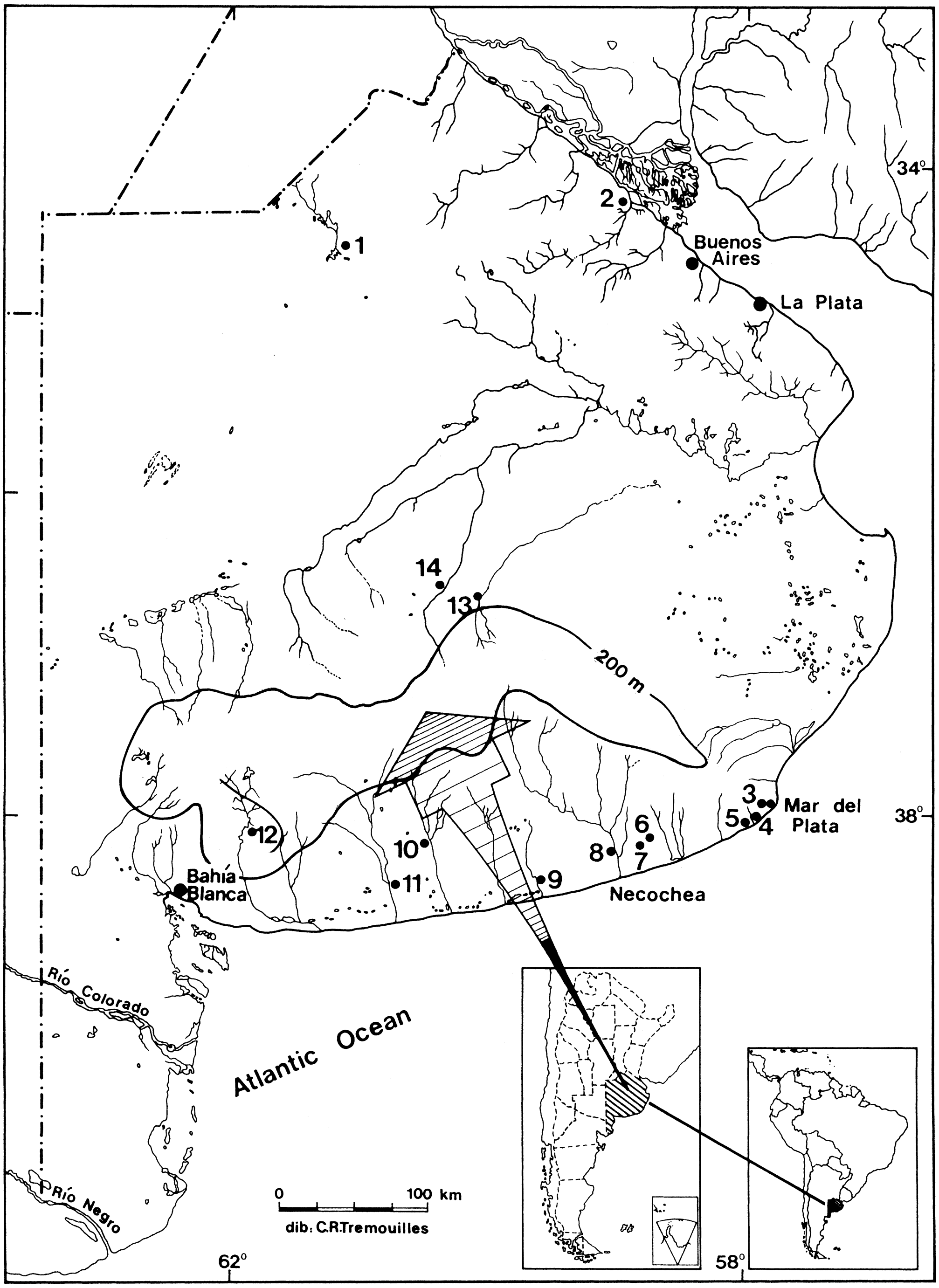


Fig. 1. Map depicting the Pampean region areas over 200 m and localities mentioned in the text.

1. Introduction

Traditionally, the terms Pampas and Pampean area were assigned to the plains that encompass the provinces of Buenos Aires, southeastern Córdoba, southern Santa Fe, eastern La Pampa and southern Entre Ríos (central-eastern Argentina; Daus, 1946; Fig. 1). The Pampean area coincides in part with the zoogeographic Pampean Dominion in the sense of Ringuelet (1961) (Fig. 2). The Pampean dominions of zoogeographers (and phytogeographers) also involve neighbouring Uruguay and portions of southern Brazil. In this paper, we refer only to the Argentinean area. This region is mostly characterized by grasslands with an impoverished subtropical Brazilian fauna without endemics at the species level.

The Pleistocene and Holocene continental beds in the studied area are extremely rich in mammal remains but biostratigraphic studies had been rarely done before the 1980’s (Cione and Tonni, 1995a,b,c).

Recent field work in the Pampean area yielded abundant new information about stratigraphic and geographic distribution of mammals at the end of the Cenozoic (Pleistocene: Tonni et al., 1992; Tonni and Cione, 1994, 1995; Cione and Tonni, 1995a,b; Pardiñas, 1995; Pardiñas and Lezcano, 1995; Holocene: Tonni, 1990, 1992; archaeological sites: Politis et al., 1983; Salemme, 1983; Salemme and Tonni, 1983). However, the taxonomy of many taxa is presently under revision (see papers in Alberdi et al., 1989).

Vertebrates (particularly mammals) have shown to be important indicators of environmental change. The late Cenozoic climatic changes greatly affected the Pampean fauna as in other parts of the world. However, Prieto (1996) suggested that paleo-environmental reconstructions based on Late Pleistocene fauna “are largely problematic because many are based on studies of extinct taxa”. Quite to the contrary, nearly all paleoclimatic inferences based on mammals of the Pampas rely exclusively on extant species (see Tonni, 1990, 1992; Tonni et al., 1992; Tonni and Cione, 1994; Cione and Tonni, 1995a; Pardiñas, 1995; Pardiñas and Lezcano, 1995).

In addition, many new radiocarbon and magnetostratigraphic data are presently available (Figini et al., 1978, 1989, 1995; Gómez et al., 1988, 1989; Huarte and Figini, 1988; Figini, 1992; Figini and Carbonari, 1994; Tonni et al., 1995; Appendix A).

Our studies suggest that the Pleistocene and early-mid Holocene fauna in the Pampean region was different to that present in the area today. The biocenoses dramatically differ not only by the presence of the large extinct mammal species but by the occurrence of many species that presently inhabit the arid territories of Patagonia and central Argentina.

We found that during most of the Late Pleistocene and Holocene climate in the Pampas seems to have been arid and cold with (very?) short wetter periods. The present climate in the area seems to have been recently established. In this paper, we review the mammal record of the Pampas as a proxy of the major climatic events that occurred during the latest Pleistocene and Holocene. The discussion is focused on past changes in temperature and precipitation as interpreted from the mammal record at several sites in the Buenos Aires Province in order to contrast the hypothesis proposed above. The mammal record is then compared with other sources of paleoenvironmental information from South America and the polar areas in the framework of new radiometric data. Finally, paleogeographic maps for the last glacial maximum and the mid-Holocene in the Pampean area are provided.

2. Stratigraphic setting

The Pampean area is part of a huge sedimentary basin with horizontally arranged strata ranging from, at least, the Cretaceous to the Recent (Russo et al., 1979).

Stratigraphic survey of the younger beds began in the beginning of last century (see Cione and Tonni, 1995a). Florentino Ameghino established the standard reference scale for the continental Cenozoic of South America and proposed a sequence of stages (pisos) grouped into higher-order units (or ‘formaciones’; e.g. Ameghino, 1889, 1909). Ameghino’s scale of stages (Ameghino, 1909), largely based on biostratigraphy, remains valid even today in the chronologic local standard scale of southern South America (Cione and Tonni, 1995a,c). The late Cenozoic stratigraphy was later studied by other authors (e.g. Frenguelli, 1957; Fidalgo et al., 1975, 1991; Fidalgo, 1983; Rabassa, 1985; among others).

The Quaternary time scale includes the Ense-

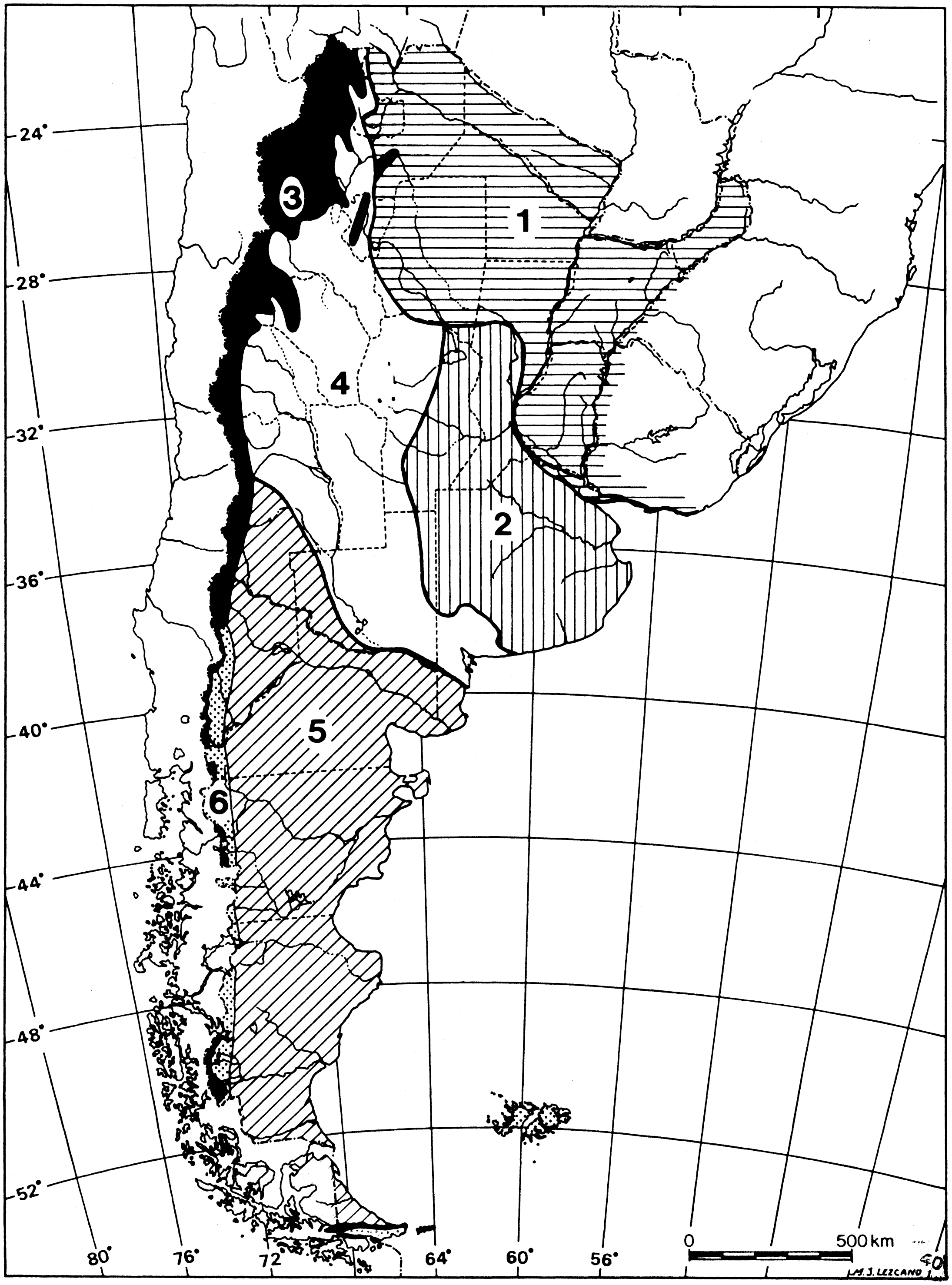


Fig. 2. Phenetic zoogeographic scheme of Argentina (Ringuelet, 1961). Guayano–Brazilian subregion: *1* = Subtropical Dominion; *2* = Pampean Dominion. Andean–Patagonian subregion: *3* = Andean Dominion; *4* = Central or Subandean Dominion; *5* = Patagonian Dominion. Araucanian subregion: *6* = Austral–Cordilleran Dominion.

nadan Stage, from about 2 to 0.6 Ma; the upper and lower Lujanian Stage, from about 0.6 Ma to 8500 yr B.P., and the Platan Stage, from 8500 yr B.P. to the 16th century, when the Spaniards arrived to the Pampas (Fig. 3). The present biostratigraphic, basis of the late Cenozoic chronostratigraphic units are the Zones of *Tolypeutes pampaeus* (Ensenadan Stage), *Megatherium americanum* (early Lujanian Stage of Pascual et al., 1965, corresponding to Bonarian Stage of Ameghino, 1889), *Equus* (*Amerhippus*) *neogeus* (late Lujanian Stage of Pascual et al., 1965 = Lujanian Stage of Ameghino, 1889), and *Lagostomus maximus* (Platan Stage; for a complete discussion see Tonni and Cione, 1994; Cione and Tonni, 1995a,c). The Pliocene–Pleistocene boundary is within the Ensenadan Stage if the generally accepted date of 1.6 Ma is considered. However, if the lower boundary of the Pleistocene is placed at 2.5 Ma (e.g. Bonadonna and Alberdi, 1987; Mörner, 1991) the Plio–Pleistocene boundary is within the underlying Marplatan Stage (Cione and Tonni, 1995a). All those beds considered in the present paper have normal polarity and correspond to the Brunhes Chron.

The 'Pampiano' Formation is the most widely distributed Pleistocene unit in the Pampean area (Tonni and Fidalgo, 1978). The upper beds of this mostly eolian formation include mammals of the Zone of *Megatherium americanum*.

The overlying latest Pleistocene–Holocene units are informally called 'post-Pampean sediments' ('sedimentos postpampeanos'). In this paper we follow chiefly the lithostratigraphic scheme of Fidalgo (1983) and Fidalgo et al. (1991). Rabassa (1985) proposed local lithostratigraphic units for the hilly southwestern Pampean area. However, we have almost no mammal record from these units.

Fluvial silts and clays compose the Luján Formation into which river valleys are cut. The Luján Formation includes the latest Pleistocene La Chumbiada and Guerrero members and the Holocene Río Salado Member (Dillon and Rabassa, 1985; Fig. 3). The La Chumbiada Member is the 'sector pardo' and the Guerrero Member is the 'sector verde' of the more inclusive Guerrero Member of Fidalgo (1983). Two dates based on carbonate and molluscan shells were obtained from the uppermost part of the La Chumbiada Member (26,930 ± 860 and 28,900 ± 800 yr B.P.; see Figini et al., 1995). Many dates based on molluscan shells have been obtained from the Guerrero Member (between 21,040 ± 450 and 17,680 ± 400 yr B.P.; Figini et al., 1995). However, Figini et al. (1995) calculated that those dates obtained from molluscan shells are 1100 ± 140 yr too old due to the reservoir effect. This assumption may be correct given that bone collagen from the upper beds has yielded a younger date (13,070 ± 120 yr B.P.; Tonni, 1990).

The eolian silts and sands of the La Postrera and La Petrona formations were deposited in the interfluvial areas and range from the latest Pleistocene to the most recent beds (Fidalgo, 1992; Colado et al., 1995). The eolian La Postrera and La Petrona formations overlie the 'Pampiano', Luján, and Las Escobas formations. Radiocarbon dates obtained from different levels in the La Postrera Formation range from 10,860 ± 130 to 440 ± 60 yr B.P. (see Tonni, 1990).

A tchernozoid paleosoil (Puesto Callejón Viejo Soil, Fidalgo, 1983) formed on top of the Guerrero Member (Fig. 3). Fidalgo (1992) suggested that the Puesto Callejón Viejo Soil represents the Pleistocene–Holocene boundary in the Pampean region. Radiocarbon dates of *Succinea meridionalis* shells, pedogenetic calcium, and dispersed organic matter from levels which are correlated with the Puesto Callejón Viejo Soil yielded ages ranging from 8940 ± 130 to 10,070± yr B.P. (Fidalgo et al., 1986; Bonadonna et al., 1995). However, the correlation of these beds with the paleosoil remains to be confirmed.

Marine mid-Holocene sediments are exposed in areas between 0 and 5 m above present sea level in the eastern Buenos Aires Province. These beds are referred to as Las Escobas Formation (Fidalgo et al., 1973; Fidalgo, 1979, 1983) and 'Platense' (Frenguelli, 1957; Fig. 3). Molluscan shells from marine beds have been dated to 7140 yr B.P. in the Río Quequén Grande (Isla et al., 1986; Fig. 1) and 6190 yr B.P. at the mouth of the arroyo Las Brusquitas (Fidalgo and Tonni, 1983; Fig. 1).

In the river valleys, no extinct mammals were found in the Río Salado Member of the Luján Formation. The Zone of *Lagostomus maximus* begins at the base of this member (Cione and Tonni, 1995c). The Río Salado Member is correlated at least in part with the middle Holocene Las Escobas Forma-

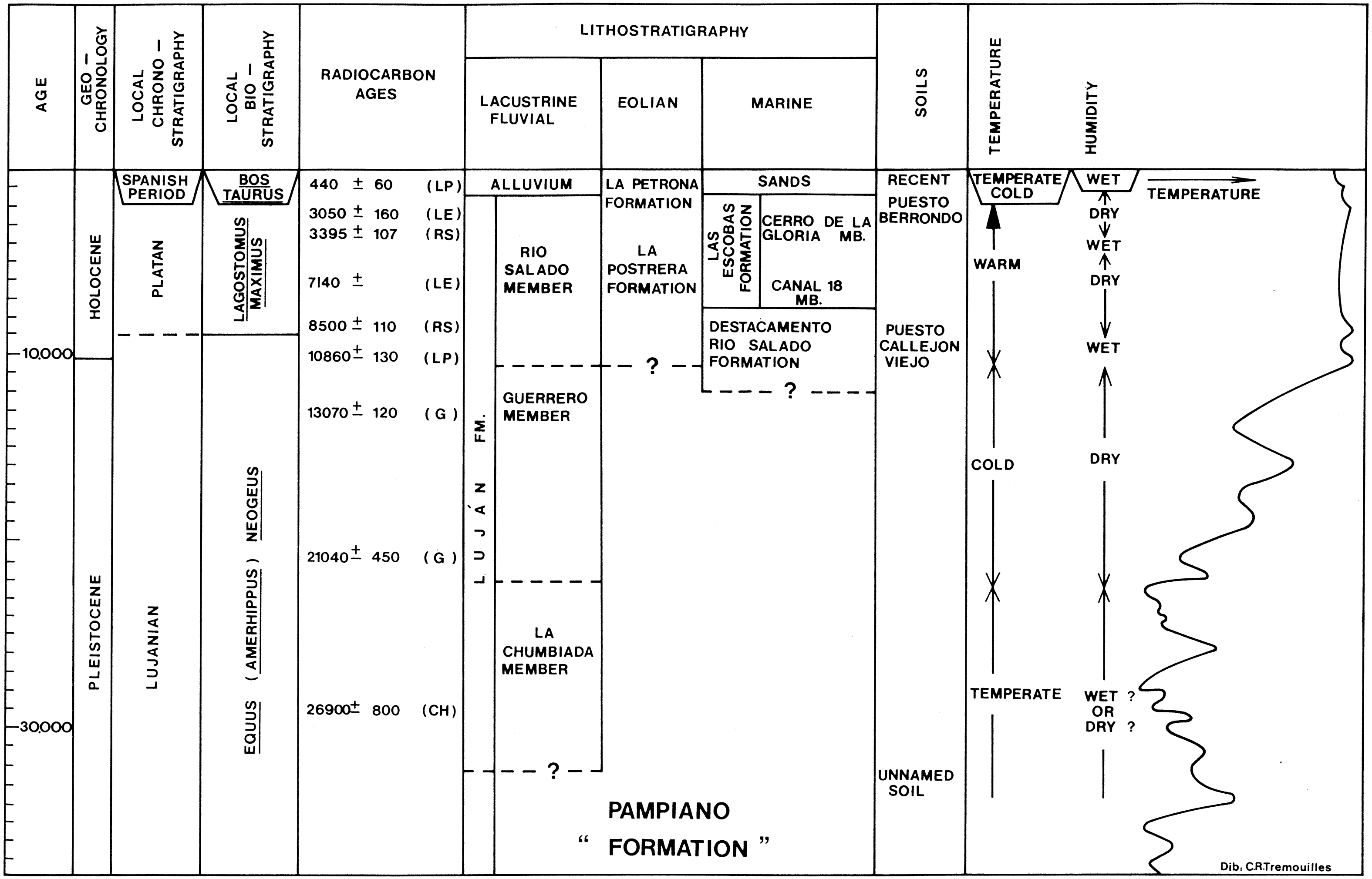


Fig. 3. Diagram depicting Late Pleistocene and Holocene continental and marine lithostratigraphic units and paleosoils of the Pampean area (Fidalgo, 1983; Fidalgo et al., 1991), the local time and biostratigraphic scales (Cione and Tonni, 1995a,c), some radiocarbon dates (see Appendix A), some local climatic events, and the temperature curve in Greenland showing the rapid climatic turnovers (adapted from Kerr, 1993). The Greenland temperature curve does not compare exactly with the Southern Hemisphere paleotemperatures.

tion marine beds (Tonni and Fidalgo, 1978; Fidalgo, 1979). The Las Escobas Formation was dated between ca. 6500 and 2600 yr B.P. (Fidalgo, 1979). Arid climate generated the erosion of part of or the entire Puesto Callejón Viejo Soil (Fidalgo, 1979). The sediments included in this soil were redeposited as darker beds intercalated between light-coloured layers of the Río Salado Member. At the same time the eolian sediments of the La Postrera Formation were deposited on the higher land surface (Fidalgo, 1979).

Several radiocarbon ages based on molluscan shells were obtained from the Río Salado Member in sections at the arroyo Tapalqué ranging between 9710 ± 110 and 8810 ± 140 yr B.P. (Fig. 1). These dates seem too old in comparison with many other dates based on bone collagen from the lower part of the La Postrera Formation which includes extinct mammals of the Zone of *Equus* (*Amerhippus*) *neogeus*. However, when corrected to account for the reservoir effect, these ages get closer to those of La Postrera Formation.

3. Zoogeography

For southern South America Ringuelet (1961) recognized three zoogeographic subregions with several dominions (Fig. 2).

Guayano–Brazilian subregion

(1) Subtropical Dominion. This dominion encompasses northeastern Argentina reaching the Río de la Plata estuary. Its fauna inhabits areas with warm and wet climate and forests or savannas.

(2) Pampean Dominion. This dominion occupies most of the Pampas of Argentina. The area has few endemics and is mainly characterized by absence of taxa. The animals occurring in the Pampas are fundamentally subtropical elements, with some Subandean and Patagonian taxa. Very few mammal subspecies are exclusive of this dominion (e.g. the fox ‘*Pseudalopex*’ *gymnocercus antiquus*, referred to the genus *Lycalopex* by Zunino et al., 1995; *Lagostomus maximus maximus*; Ringuelet, 1955). The Pampas constitute a giant, very extensive, ecotone between the warm and wet Brazilian faunas and the cold and arid western and southern faunas prevailing in Patagonia today. The predominant vegetation is herbaceous steppe, with some grass-dominated steppes, psammophilous steppes, halophilous steppes, riparian woods, and diverse types of aquatic vegetation. The climate is wet and temperate.

Andean–Patagonian subregion

(3) Andean Dominion. This dominion encompasses areas in western Argentina over 3000 m of altitude.

(4) Central or Subandean Dominion. This dominion occupies northwestern and central Argentina. Its fauna is fundamentally Brazilian but adapted to arid–semiarid temperate environments.

(5) Patagonian Dominion. This dominion encompasses extra-Andean Patagonia with a northern boundary in the rivers Desaguadero and Colorado. The existing fauna corresponds to an arid and cold temperate climate.

Araucanian subregion

(6) Austral–Cordilleran Dominion. This dominion encompasses the southernmost part of the Cordillera de los Andes including Tierra del Fuego and the Malvinas Archipelago. Its fauna is adapted to wet and cold climate and it is highly endemic.

4. Present climate

The Southern Hemisphere climate is controlled by semi-permanent pressure fields of the sub-tropical high-pressure cells South Atlantic and South Pacific anticyclones and temperate low-pressure cells (Clapperton, 1993a). Air mass movement associated with seasonal fluctuations of these pressure systems is primarily responsible for the various climate types over South America (Clapperton, 1993a; Figs. 4 and 5). Related to the general atmospheric circulation and to the topography, there are two main climatic dominions in southern South America: the Atlantic and the Pacific. A zone called the arid diagonal crosses southern South America from the northwest to southeast separating both dominions. The Pampean area is primarily located near the boundary between the Atlantic and the Pacific influence. Humidity is mainly supplied by eastern and northeastern warm winds. As a consequence, the isohyets in the Pampean area follow approximately a northwest–southeast direction.

Iglesias (1981) proposed a climatic subdivision of Argentina. In this classification, the climate type of

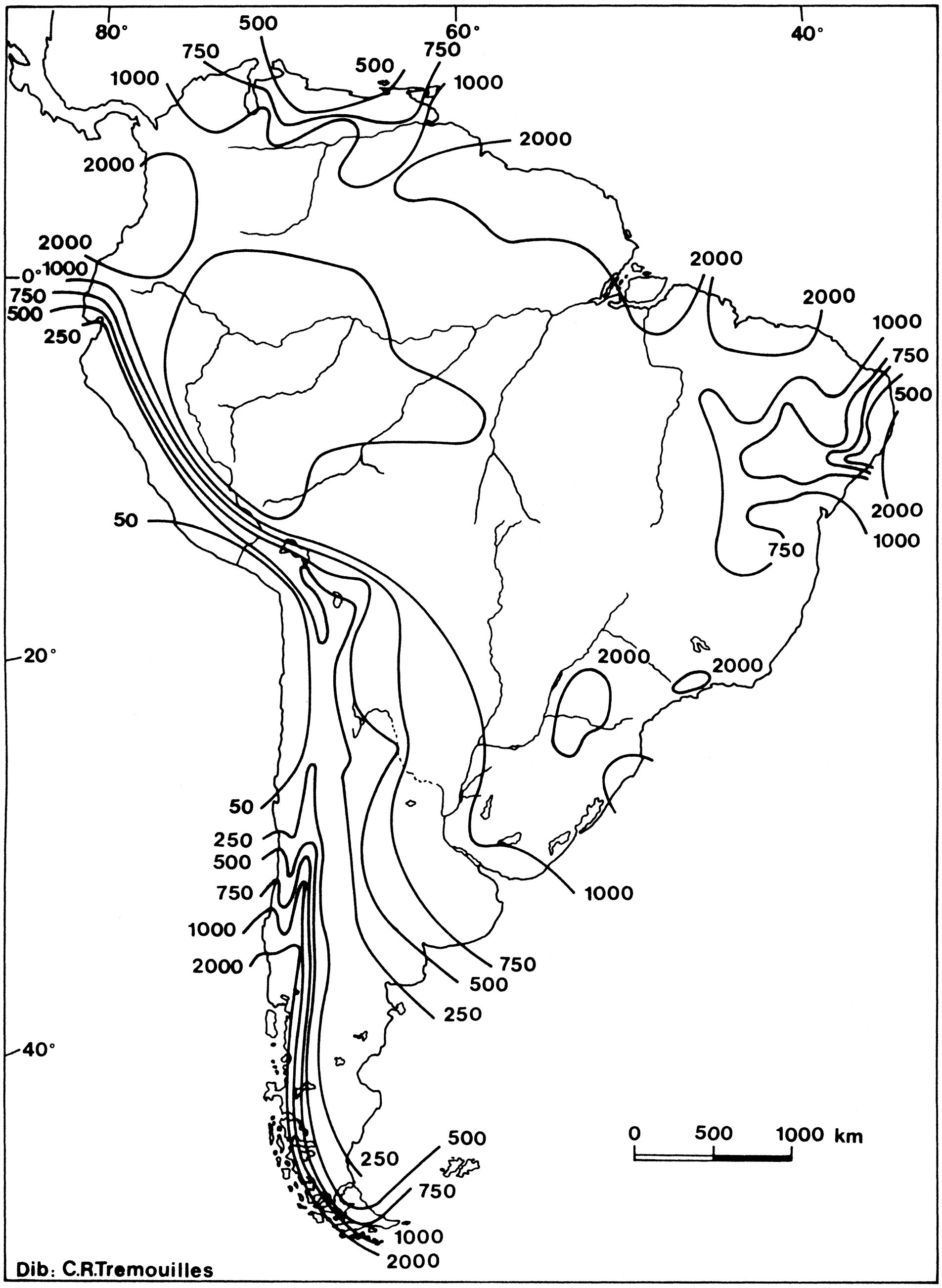


Fig. 4. Mean annual precipitation in South America (modified from Clapperton, 1993a).

the Pampean area is characterized as 'humid temperate of the Plains' in the east with annual rainfalls of 1200 to 800 mm and 'subhumid temperate of the Plains' in the west with 800 to 500 mm. Mean annual temperature in the Pampean area is between 14° and 20°C. There is no dry season throughout the area but a decrease in precipitation occurs at the end of summer and during winter. The Sierras Australes

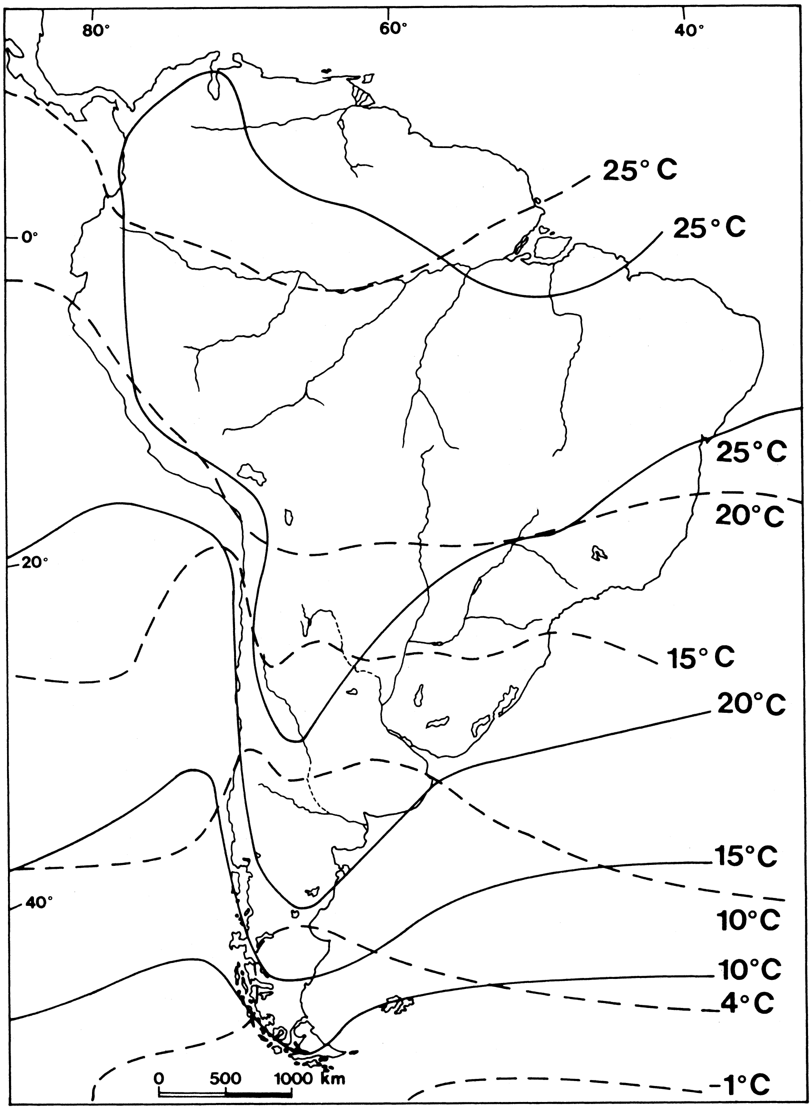


Fig. 5. July (winter, broken lines) and January (summer, full lines) mean temperatures in South America (modified from Clapperton, 1993a).

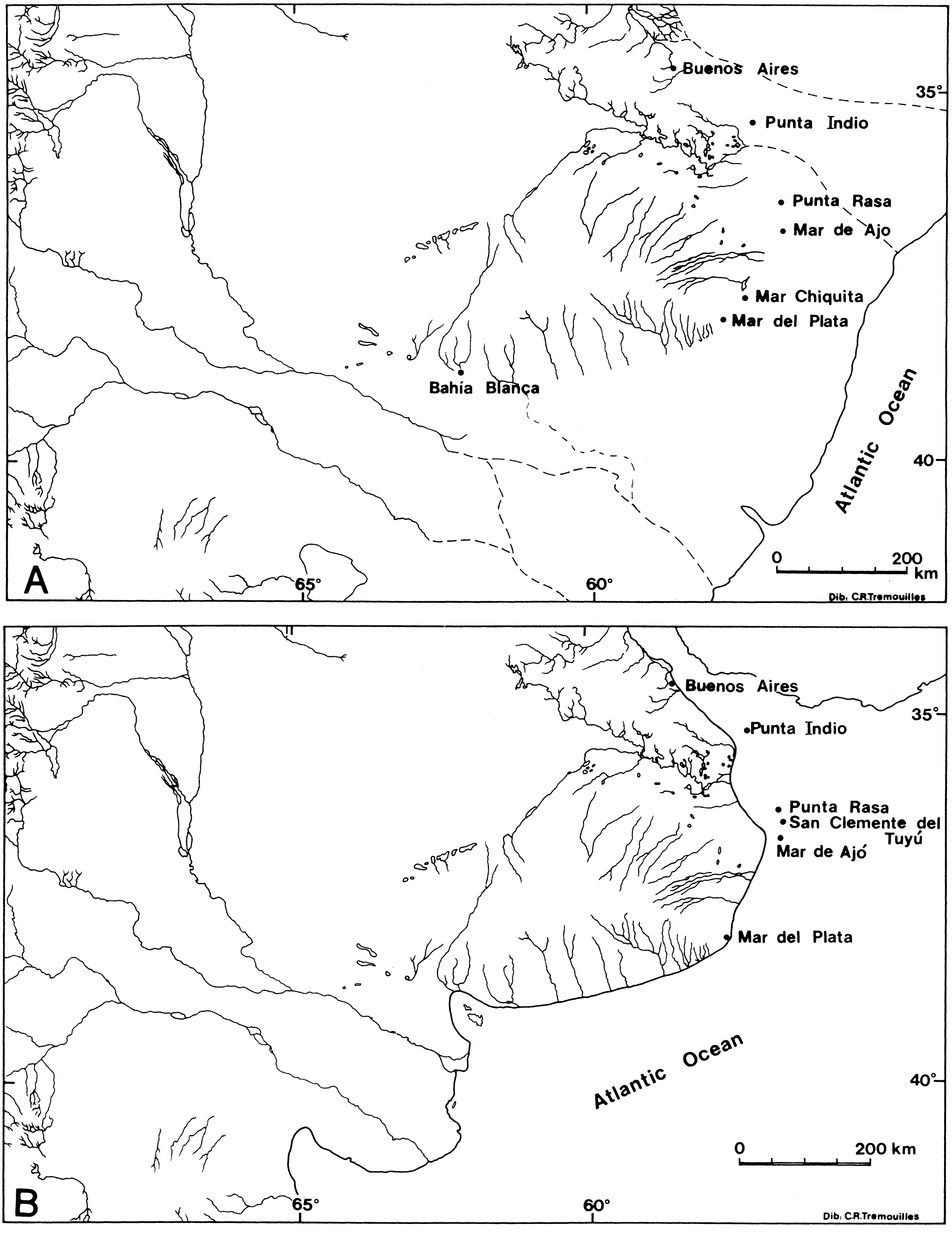
and Septentrionales, climate was called 'temperate of the Sierras' (Iglesias, 1981).

In northern Patagonia, Iglesias (1981) recognizes the climates 'semiarid and arid temperate of the Meseta'. These climates are transitional between the Atlantic Dominion and the Pacific Dominion. The 'semiarid temperate of the Meseta' climate has an average annual rainfall of less than 300 mm and the 'arid temperate of the Meseta' 100 to 200 mm.

5. Some comments on the South American latest Cenozoic climate

Terrestrial studies addressing the late Cenozoic changes in glacier extent in southern South America began with Caldenius (1932) and continued, especially in Patagonia, with the contributions by Feruglio (1949), Groeber (1952), Flint and Fidalgo (1964), and others.

During each glaciation, most of the Pampean re-


Buenos Aires
Punta Indio
Punta Rasa
Mar de Ajo
Mar Chiquita
Mar del Plata
Bahía Blanca
Atlantic Ocean
35°
40°
65°
60°
0 200 km
Dib: C.R.Tremouilles
A
Buenos Aires
Punta Indio
Punta Rasa
San Clemente del Tuyú
Mar de Ajó
Mar del Plata
Atlantic Ocean
35°
40°
65°
60°
0 200 km
Dib: C.R.Tremouilles
B

gion was supposed to have had a colder and drier climate than today, similar to that of northeastern Patagonia (Tonni and Fidalgo, 1978; Clapperton, 1993a,b). In South American tropical areas, temperatures during the LGM (Last Glacial Maximum) seem to have been 2° to 6°C (4° ± 2) lower than today (van der Hammen and Absy, 1994; Broecker, 1996). Temperatures in Antarctica during the LGM apparently were 5°C lower than today or more (Bender et al., 1997).

During the LGM, the eastern part of southern South America greatly expanded due to a sea level drop of about 120 m (Caldenius, 1932; Clapperton, 1993a,b). The coastline during the LGM was located 300 km or more to the east of the present coastline in some latitudes (Fig. 6a, Fig. 7). Today, winds carrying humidity into the Pampean area come mainly from the northeast across Paraguay, southern Brazil, and Uruguay. The Uruguayan and southern Brazilian coast did not change greatly with sea level drop. Therefore, the drier climate suggested for glacial times would not be due to increased continentality.

In the Chilean and Peruvian Andes a major glacial advance was dated at ca. 14,000 yr B.P. (Clapperton, 1993a). On the basis of fossil Coleoptera, Ashworth and Hoganson (1985) found that the climate was relatively constant after 14,000 yr B.P. in southern Chile.

During the period called Younger Dryas (about 11,000–10,000 yr B.P.), temperature dropped significantly in Europe, but also in South America (Heusser and Rabassa, 1987; Markgraf, 1989; Rabassa and Clapperton, 1990).

At about 9000 yr B.P. an important rise in temperature was recognized in South America (Heusser et al., 1981). In Central Chile, the temperature was supposed to rise 3–4°C, but the climate remained and (Heusser and Streeter, 1980; Heusser et al., 1981).

The Holocene optimum climaticum period (hypsithermal authorum) has been dated in southern South America at about 7600–6000 yr B.P. (Clapperton, 1993b). The temperature rose ca. 1–2°C (Budyko et al., 1994). A portion of a Holocene marine unit of the eastern Pampean area (Las Escobas Formation) was deposited during the Holocene optimum climaticum period (Tonni and Fidalgo, 1978; Fig. 6b, Fig. 7). Aridity was detected in Bolivia at 7700–3600 yr B.P. with a drop of level in Lago Titicaca (Wirrman and Oliveira de Almeida, 1987).

The Little Ice Age has been modelled by a 2°C drop in mean annual temperature from AD 1200 to AD 1850 in the Northern Hemisphere (Campbell and Mcandrews, 1993). Dendrochronological studies for several sites in Tierra del Fuego show consistently that a severely cold or cold-dry episode took place about AD 1590–1870. This event was correlated with the Little Ice Age (Boninsegna, 1992).

6. Discussion

6.1. Late Lujanian (Zone of Equus (Amerhippus) neogeus)

Mammal remains have been collected from beds of Lujanian age since the 18th century. Lujanian assemblages consist of species of extinct South American clades such as Notoungulata and Litopterna, extinct species of North American immigrant clades, and extant species of endemic and immigrant taxa. More recent studies considered that the assemblages indicated a climate more arid and possibly colder than at present (e.g. Frenguelli, 1950; Tonni and Fidalgo, 1978; Tonni and Cione, 1995; for a different point of view, see Pascual, 1970).

Abundant mammal fossils have been recovered from the Paso Otero section near the Río Quequén Grande (Tonni and Fidalgo, 1978; Tonni and Laza, 1980; Prado et al., 1987; Fig. 1). Both the Guerrero and La Chumbiada members had been referred to the LGM (Tonni and Fidalgo, 1978). However, recent field work allows this hypothesis to be partly modified.

Arid and/or cold climate indicators have been reported in other Guerrero Member outcrops: the marsupial *Lestodelphys halli*, the rodent *Eligmodontia typus*, the mustelid *Lyncodon patagonicus*, the canid *Dusicyon griseus*, and the abundant rodent *Mi-*

Fig. 6. Maps depicting central eastern Argentina: (A) at 18,000 years B.P.; (B) at 7000 years B.P. The present rivers are depicted in all maps. Hypothesized courses of some rivers in the presently inundated area are shown in (A).

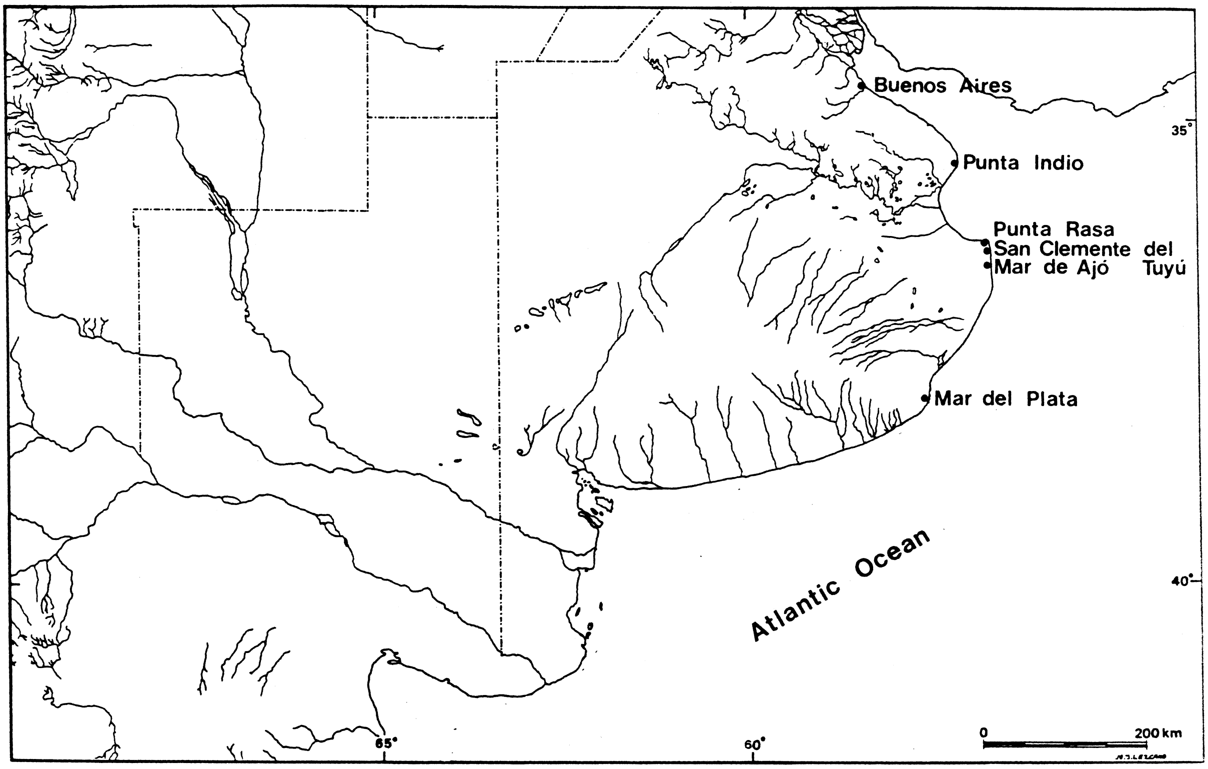


Fig. 7. Map depicting present-day central eastern Argentina.

crocavia australis (Quequén Salado–Indio Rico, Río Luján, and in correlated beds at Punta Hermengo; Tonni and Fidalgo, 1982; Tonni et al., 1985; Alberdi et al., 1989; Fig. 1). Those mammals have their oldest occurrences in the Guerrero Member. The geographic distribution of the rodent *Microcavia australis* encompasses arid areas and excludes almost completely that of *Cavia aperea* (Table 1). Both caviids are sympatric today only in the southwestern Buenos Aires Province today, in the northern part of the Patagonian Dominion (Contreras, 1973; Galliari et al., 1991).

A dramatic faunal turnover occurred between the La Chumbiada and Guerrero members deposition. (1) Several extant species occurring in the La Chumbiada Member have not been recorded in the Guerrero Member (the rodents *Dolichotis patagonum* and *Lagostomus maximus* and the canid *'Pseudalopex' gymnocercus*). (2) Cervids are abundant and more diverse in the La Chumbiada Member than in the Guerrero Member. (3) The camelid *Lama gracilis*, though occurring in both members, is more frequent in the La Chumbiada Member (Menegaz et al., 1989). (4) Three large herbivores (the litoptern *Macrauchenia patachonica*, the tardigrade *Megatherium americanum*, and the notoungulate *Toxodon platensis*) seem to occur only in the Guerrero Member. Pardiñas and Lezcano (1995) reported the occurrence of the Brazilian cricetid *Lundomys* in the Guerrero Member at Paso Otero (Table 1). However, the material (a fragmentary M1) actually comes from channeled sediments in a paleovalley overlying the Guerrero Member (Tonni and Fidalgo, 1978; Prado et al., 1987).

The faunal turnover represents a decrease in frequency and diversity of browsers, mainly cervids, and an increase of huge grazers weighing more than a ton. This increase in grazers and the presence of the Patagonian rhea *Pterocnemia* was interpreted as evidence for a vegetational shift in response to a more arid and colder climate (Prado et al., 1987; Tonni and Cione, 1995). The $^{18}O/^{16}O$ ratio in freshwater

Table 1
Temperature and humidity range of several recent mammals (Cabrera, 1959, 1960; Redford and Eisenberg, 1989; Goin and Carlini, 1989; Vizcaíno et al., 1995)

Arid and cold	Arid and warm	Arid (wide range of temperature)	Wet and warm	Wet and temperate	Wide ranging
Lestodelphys halli	*Thylamys pusillus*	*Eligmodontia typus*	*Scapteromys aquaticus*	*Pseudalopex gymnocercus*	*Felis* sp.
Zaedyus pichiy	*Tolypeutes matacus*	*Dusicyon culpaeus*	*Holochilus brasiliensis*	*Oxymycterus rufus*	*Chaetophractus villosus*
Dusicyon griseus	*Galea musteloides*	*Dolichotis patagonum*	*Lundomys molitor*	*Dasypus hybridus*	*Calomys* sp.
Lyncodon patagonicus	*Dolichotis salinicola*	*Microcavia australis*	*Cavia aperea*		
Lama guanicoe	*Pseudoryzomys wavrini*	*Reithrodon auritus*	*Bibimys*		
	Lagostomus maximus	*Phyllotis darwini*			
	Graomys griseoflavus	*Ctenomys* sp.			

gastropod shells from the Guerrero Member at Paso Otero also suggested cooler climates (Bonadonna et al., 1995; Fig. 1).

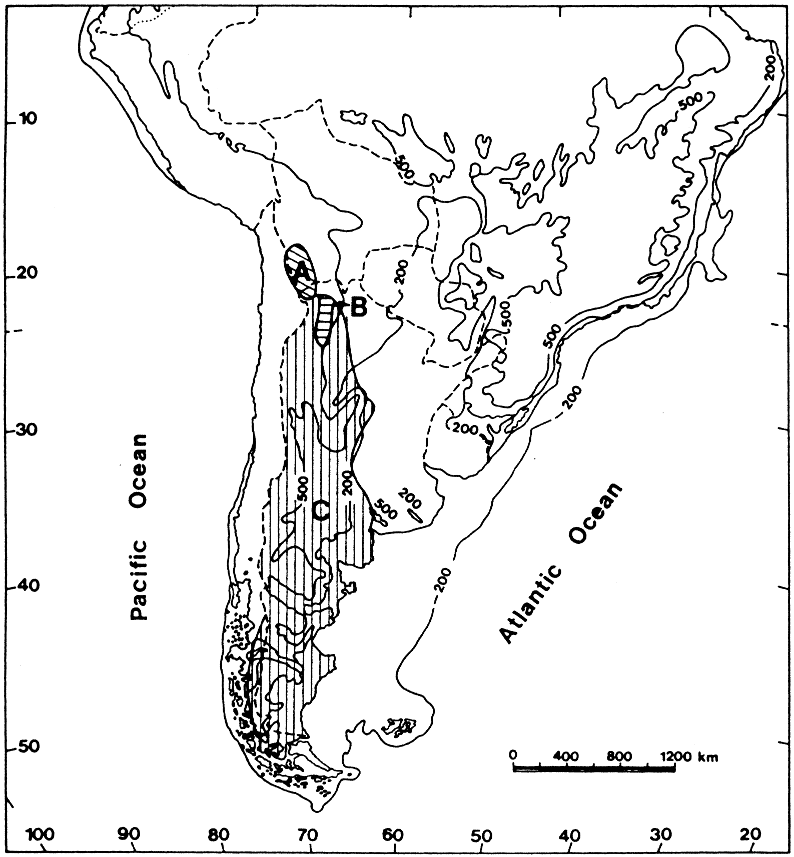
Bonadonna et al. (1995) attributed the La Chumbiada Member beds to a short warmer period during the last glacial cycle at about 25,000 to 30,000 yr B.P. This interval could be related to isotopic Stage 2 shown by ice core records from Antarctica and pollen data from southern South America (Markgraf et al., 1986; Ledru, 1993). However, it would also be possible to refer the assemblage of the La Chumbiada Member to the last interstadial (about 60,000–35,000 yr B.P.; isotopic Stage 3; Clapperton, 1993b).

Glacial geomorphologic data suggest that the LGM occurred at 20,000 to 18,000 yr B.P. in the South American Andean region (Clapperton, 1993b). Pollen data indicate very cold and dry climates for the Andean region between 25,000 and 12,000 yr B.P. (Clapperton, 1993b). All the Pampean area apparently was covered by desert vegetation growing on sand dunes and loess fields (Clapperton, 1993b, his figs. 6a, b). Palynological evidence from a section at the Río Naposti Grande near Bahía Blanca (southern Buenos Aires Province) indicates a halophytic steppe representing arid–semiarid climatic conditions in that locality for the Late Pleistocene (Quattrocchio et al., 1993).

The eolian sand and loess distribution suggests that cold and dry environmental conditions similar to those of Patagonia today extended over 750 km farther northeastwards than today during the Late Pleistocene until 8500 yr B.P. (Iriondo and García, 1993). There is no record in the area of a warmer episode during the Late Glacial such as the Bølling event.

The lower part of the eolian La Postrera Formation includes extinct mammal fauna and correlates with the upper part of the Guerrero Member. In the Tres Arroyos and Loberia localities, radiocarbon ages range from 11, 590 ± 90 to 7320 ± 50 yr B.P. (Fidalgo, 1983; Politis et al., 1983; Fidalgo et al., 1986). Some of these were obtained from collagen of extinct mammal bones from paleoindian archaeological sites. The mammal assemblage is similar to that of the Guerrero Member.

The La Postrera Formation was deposited in a dune and loess field environment. The mammal fauna corresponds to that of the recent Patagonian and Central dominions (Figs. 2 and 8–11). Several mammals extended their distribution to the eastern and northern Pampean area: the mustelid *Lyncodon patagonicus*, the dasypodid *Zaedyus pichiy*, the caviids *Dolichotis patagonum* (Arroyo Seco) and *Microcavia australis* (Lobería; Fig. 1), and the marsupial *Lestodelphys halli* (Junín; Fidalgo and Tonni, 1981;



Dib: C.R.Tremouilles

Fig. 8. Recent distribution of several mammal taxa: *A* = *Microcavia niata*; *B* = *Microcavia shiptoni*; *C* = *Microcavia australis* (Cabrera, 1960; Redford and Eisenberg, 1992).

Prado et al., 1985; Fidalgo et al., 1986; Figs. 1 and 8–11; Table 1).

Palynological evidence in putative Late Pleistocene sediments in a section at the Bajo San José (Río Sauce Grande, southern Buenos Aires Province, Fig. 1) indicates extremely arid to semiarid conditions (Quattrocchio et al., 1993). However, mammal taxa recorded indicate that the bearing beds are not Lujanian (Late Pleistocene) but late Ensenadan (younger than 0.6 Ma but older than about 0.5 Ma; A.L. Cione et al., in prep.). This locality was erroneously cited as 'near Sauce Chico' by Prieto (1996, p. 84), who stated that the vegetation represented there was "xerophytic woodland associated with psammophytic and halophytic steppe." However, Quattrocchio et al. (1993) suggest instead that the vegetation had shrubby but not woody elements.

Curiously, Dillahay et al. (1992) considered that a cool but wet climate occurred in the Pampean area during the Late Pleistocene until 11,000 yr B.P and represented the 'Pampa grassland' in the same areas as today (their fig. 2). No evidence support these statements.

6.2. Platan (Zone of *Lagostomus maximus*)

The Puesto Callejón Viejo Soil in the top of the Guerrero Member is a tchernozoid soil that must have developed during a relatively warm and wet climate. Fidalgo (1979) considered that this soil separates the Pleistocene and Holocene. No mammal remains were found in this soil. This pedogenetic event probably coincides with the general warming of the early Holocene of the Northern Hemisphere

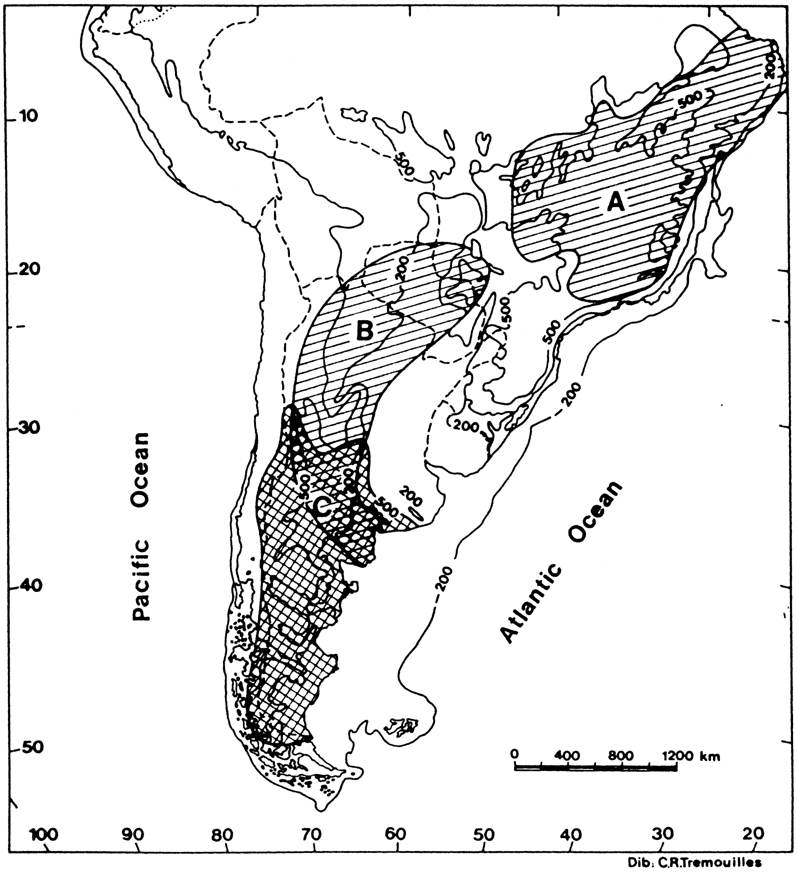


Fig. 9. Recent distribution of several mammal taxa: *A* = *Tolypeutes tricinctus*; *B* = *Tolypeutes matacus*; *C* = *Zaedyus pichiy* (Cabrera, 1960).

(about 9000 B.P.) which has also been identified in central Chile (Heusser and Streeter, 1980; Heusser et al., 1981; Ritchie et al., 1983).

In the Paso Otero and Quequén Salado sites, Bonadonna et al. (1995) pointed out that the lower part of the Río Salado Member is isotopically similar to the underlying Guerrero Member. Bonadonna et al. (1995) suggested that a similar arid climate occurred in the Late Pleistocene and the early Holocene.

Páez and Prieto (1993) studied pollen in a section of eolian sediments containing archaeological remains inside a rocky shelter and a nearby eolian section in southeastern Buenos Aires Province (Cerro La China; Fig. 1). Pollen assemblages coming from sediments dated at 10,790 yr B.P. indicate an environment of locally high effective moisture; intervals of high pollen concentration probably relate with a paleosoil. Zárate and Flegenheimer (1991) suggested that the wet period extended to 6500–5000 yr B.P. These wet environments probably correspond to local conditions since at that moment the eolian sediments and mammal remains of La Postrera Formation indicated arid climates (Tonni, 1990, 1992; Tonni and Cione, 1995; see also Fidalgo, 1979; Servant et al., 1981; Heusser, 1983).

Several species of large South American mammals became extinct at the beginning of the Holocene. There is a diverse extinct fauna in La Postrera Formation at the site Arroyo Seco (Politis et al., 1983; Fidalgo et al., 1986; Tonni, 1990; Fig. 1): *Megatherium americanum* cf. *Mylodon*, *Equus* (*Amerhippus*), *Hippidion*, *Toxodon*, and *Hemiauchenia*. Bones of *Megatherium americanum* were dated at 8390 ± 140 and 7320 yr B.P. (Politis et al., 1983).

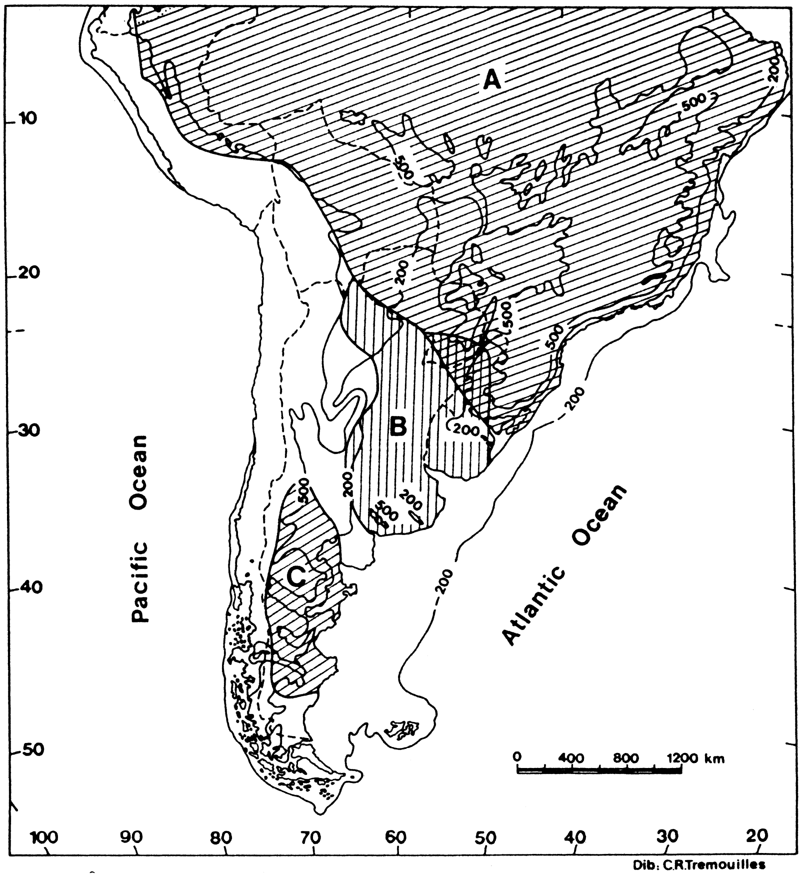


Fig. 10. Recent distribution of several mammal taxa: *A* = *Dasypus novencinctus*; *B* = *Dasypus hybridus*; *C* = *Lestodelphys halli* (Goin and Carlini, 1989; Vizcaíno et al., 1995).

The glyptodont *Doedicurus clavicaudatus* is another late representative of the large extinct mammals. Politis (1984) and Rabassa (1985) claim that the bearing beds in the La Moderna site were dated to about 6000 yr B.P. However, this date is presently considered unreliable. Those beds with *D. clavicaudatus* have been dated to about 7500 yr B.P. (Politis et al., 1983). Therefore, the extinction process extended in South America well into the Holocene, as has also been shown in Venezuela (Tonni, 1992; Linares, 1993).

Molluscan taxa found in the marine Las Escobas Formation along the eastern Buenos Aires Province indicate that the warm water fauna moved southwards (Aguirre, 1993). The transgressive facies of the Las Escobas Formation is correlated with the mid-Holocene temperature rise. The expansion of the amphibious cricetid rodent *Scapteromys* in the fluvial beds between the Guerrero and Río Salado members in central Buenos Aires Province corresponds to a warmer climate (7500 yr B.P.; La Moderna; Tonni, 1990; Pardiñas, 1995). This amphibious cricetid presently inhabits drainages in the Subtropical Dominion even in dry areas. Therefore, its occurrence certainly indicates a warmer climate, but not necessarily widely established wetter conditions.

Iriondo (1993) and Iriondo and García (1993) proposed that during the period 8500–3500 yr B.P. the continental Pampean climate was wet and subtropical to tropical (see also Rabassa, 1985; Aguirre and Whatley, 1995). However, no evidence has been given sustaining permanently wetter climates. In addition, palynological evidence from several localities in southern Buenos Aires Province suggests that the

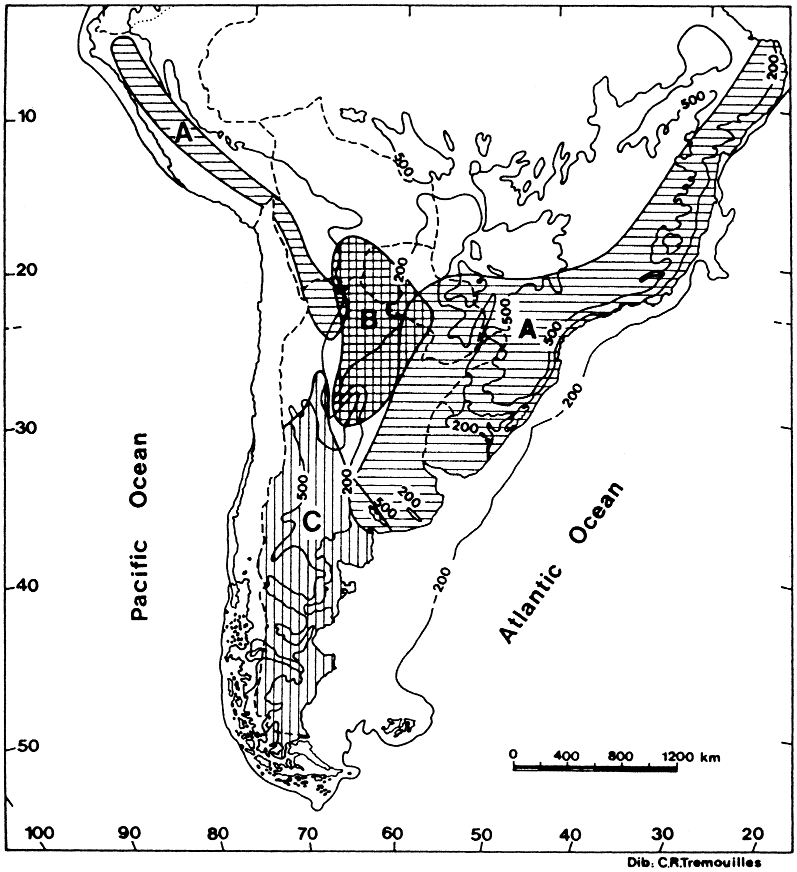


Fig. 11. Recent distribution of several mammal taxa: *A* = *Cavia* spp.; *B* = *Dolichotis salinicola*; *C* = *Dolichotis patagonum* (Cabrera, 1960).

climate in the mid-Holocene was wet but temperate (Grill, 1995, and references therein). Remarkably, most of the mammal taxa recorded in the lower, middle, and most of the upper Holocene indicate an arid to semiarid climate (see also Clapperton, 1993a).

Owl pellets in late Holocene eolian beds at Centinela del Mar include a non-analogue assemblage (Fig. 1): Chacoan (*Pseudoryzomys*), subtropical (*Bibimys*, *Desmodus*), Central and Patagonian (*Eligmodontia typus*), Central (*Phyllotis* cf. *darwini*), and Pampean (*Cavia aperea*) cricetid rodents and bats denote a mosaic of microenvironmental conditions in a climate warmer and at least locally more arid than the area today (Pardiñas, 1995; Pardiñas and Tonni, 1996; Table 1).

In an archaeological pre-Hispanic site in the arroyo Cortaderas, mammal-bearing beds are considered younger than 2500 yr B.P. and older than the 16th century (Salemme, 1987; Fig. 1). The mammal assemblage includes Central and Patagonian taxa such as the dasypodiid *Tolypeutes* sp. and *Zaedyus pichiy*, the mustelid *Lyncodon patagonicus*, and the canid *Dusicyon culpaeus* which indicate an arid to semiarid and possibly colder climate (Politis et al., 1983; Table 1).

A non-analogue assemblage occurs in sediments dated at 1960 ± 100 yr B.P. near Bahía Blanca (lat. 38°30′S; Fig. 1). In this site, the rodent *Cavia aperea* is found along with arid and warm indicators such as *Thylamys pusillus* and *Graomys griseoflavus* and an arid and cold indicator as *Lestodelphys halli* (Table 1). This assemblage would be the consequence of the onset of warm and humid climates replacing the earlier arid climates (Deschamps and Tonni, 1992).

Further east at the Zanjón Seco 2 site (Fig. 1), in beds dated at 1460 ± 50 yr B.P., arid indicators such as *Lama guanicoe* and *Zaedyus pichiy* occur (Politis and Tonni, 1982; Table 1).

An important subtropical species, the dasypodiid *Dasypus hybridus* occurs for the first time in the Pampean area in the Río Sauce Grande along with the caviid *Cavia aperea* and *Zaedyus pichiy* in beds dated at 995 ± 65 yr B.P. (Fig. 1; Salemme, 1987; Vizcaíno and Bargo, 1993; Table 1). These records could correspond to the medieval temperature rise (Crowley and North, 1991).

The Little Ice Age seems to be represented by the occurrence of arid species such as *Lama guanicoe* and *Dolichotis patagonum* in eolian beds dated at 440 ± 60 yr B.P. in southern Pampean area (site Lobería I; Tonni, 1985; Fig. 1; Table 1), and other faunal, geological and etnohistorical evidence in the Pampean area (Tonni and Politis, 1980; Politis, 1984; Ramonell et al., 1993; Kronberg et al., 1993).

The occurrence of the presently Central dasypodiid *Chaetophractus vellerosus* in the eastern Pampean area could be a relict of more arid conditions in relatively recent times (Carlini and Vizcaíno, 1987; Table 1). This edentate occurs in the Holocene marine shell accumulations (Las Escobas Formation) and eolian beds (La Petrona Formation) where edaphic vegetation associations also occur (Cabrera, 1971).

7. Conclusions

Contrasting with North American faunal associations, there are many supposedly non-analogue assemblages not only in the upper Pleistocene but also in the Holocene of the Pampean area. However, the level of resolution of the Pampean biostratigraphy is not very high and time averaging may be important.

The Greenland and Antarctic paleoclimatic studies show that during the Late Pleistocene there were many dramatic oscillations (Kerr, 1993; Jouzel et al., 1994; Bard et al., 1997). North American non-analogue assemblages were mainly explained by assuming that climates were different from the present ones (Graham, 1985; Graham et al., 1996). We have no geological or biological reasons to consider that Pleistocene climates in the Pampean area were markedly different from the climates in South America today. The Pampean area is located halfway between the humid area of the Atlantic Domain and the ‘South American arid diagonal’. The Pampean area is an ecotone between two major zoogeographic areas existing today in South America: the Brazilian and Patagonian subregions.

We suggest that most of the Pampean non-analogue assemblages actually are not tanathocenoses. The presence of mammals that today inhabit areas with different climates and faunal provinces would be related to rapid modifications in the temperature not recorded by time averaging and the relatively poor level of resolution of the Pampean fossil record.

Most climatic indicators show that the climate in the Pampean area was mostly arid since the Sanandresian (Late Pliocene) until very recently. Since the Lujanian to the mid-Holocene, the climate was predominantly colder than at present. No warm climate indicator occurs in Late Pleistocene beds in the Pampean region. Most of the mammals presently inhabiting the Pampean area are very scarce or do not occur in most of the Late Pleistocene and Holocene beds (e.g. the marsupial *Didelphis albiventris*, the armadillo *Dasypus hybridus*, the rodents *Cavia aperea*, *Myocastor coypus* and *Hydrochoerus hydrochaeris*, the carnivores *Galictis cuja* and *Conepatus chinga*).

The atmospheric circulation pattern during the LGM probably was not very different from that of the Recent. The South Atlantic anticyclon was probably located nearer to the Equator than today (Clapperton, 1993a). Easterly winds (trade winds) bring most of the precipitation to the Pampean area today. Precipitation diminishes gradually from northeast to southwest. During the LGM, the wetter easterly winds had less humidity and consequently generated aridity in the Pampean area. Additionally, the coast was located many kilometers farther east due to the sea level drop which probably influenced the diurnal temperature gradient but not necessarily precipitation. Westerlies, as today, did not bring humidity to the Pampean area. The southern Andes probably formed an even more important barrier to Pacific wet winds than today because of the extended mountain glaciation ice sheet of 1600–1800 m of altitude (Flint and Fidalgo, 1969). Due to the Andean rain shadow and the increased continentality, Patagonia would have been even more arid than today during the Late Pleistocene. Mean annual temperatures were probably colder than today reflecting the global temperature drop. However, Garleff et al. (1994) found that the center of northern Patagonia had a relatively wet climate at about 13,000 yr B.P.

All the Pampean area was covered by desert vegetation growing on sand dunes and loess fields. The combination of a temperature drop of perhaps 5ºC, the increased aridity (shown by different sources of evidence), and the composition of mammal assemblages suggest that during the LGM, the Pampean area would have had an arid and relatively cold climate similar to that prevailing today in northern Patagonia.

Most of the Malvinas current was probably surely displaced off the continental shelf due to the sea level drop. The cold water probably reached lower latitudes and encountered the Brazil current farther north than the latitude of Río de la Plata.

Mammals occurring in the Platan beds usually indicate dry but not cool conditions. Warm and probably wetter conditions coincided with a near-shore marine ingression (ca. 7000–6000 yr B.P.). A non-analogue assemblage of subtropical mammals and dry/cold indicators occurs at the latitude of 38º30′S at ca. 2000 yr B.P. Subtropical mammals that require wet conditions have been expanding southwards in the Pampean area since 1500–1000 yr B.P. However, eolian sediments in the La Postrera Formation dated ca. 440 yr B.P. yielded an arid to semiarid mammal assemblage.

Therefore, the present climatic conditions and the Pampean zoogeographic Dominion seem to have been developed much more recently than previously estimated.

Acknowledgements

The authors would like to thank the following persons and institutions. For reading drafts of the manuscript: Jorge Rabassa, Miguel Manceñido. For valuable information: Mariano Bond, U.F.J. Pardiñas. For financial support: Agencia Nacional de Promoción Científica y Tecnológica PMT-PICT 0122, CIC Resol. 1104/96 and 1303/97 and Universidad Nacional de La Plata.

Appendix A

^{14}C ages from Pampean area units

Lujá Fm.		
La Chumbiada Member (upper part)		
LP-268, *Littoridina parchappei*	28900 ± 800	Figini et al., 1995
LP-616, Calcrete	26930 ± 860	Figini et al., 1995
Guerrero Member		
LP-621, Calcrete	29850 ± 1370	Figini et al., 1995
LP-396, *Littoridina parchappei*	21040 ± 450	Figini et al., 1995
LP-292, *Littoridina parchappei*	18600 ± 400	Figini et al., 1995
LP-296, *Littoridina parchappei*	18280 ± 220	Figini et al., 1995
LP-272, *Littoridina parchappei*	17680 ± 400	Figini et al., 1995
LP-174b, *Megatherium americanum* (collagen)	13070 ± 120	Huarte et al., 1988
Sediments of similar stratigraphic position to the Puesto Callejón Viejo Soil		
LP-429, Total organic matter	8940 ± 130	Figini et al., 1995
LP-379, *Succinea meridionalis*	9710 ± 110	Figini et al., 1995
LP-418, Calcrete	10070 ± 140	Figini et al., 1995
Puesto Callejón Viejo Soil		
Beta-79439, Organic matter	9000 ± 70	Zárate et al., 1995
Río Salado Member (lower part)		
LP-505, Total organic matter	7180 ± 80	Figini et al., 1995
LP-580, $CaCO_3$	8750 ± 130	Figini et al., 1995
LP-395, *Succinea meridionalis*	8810 ± 140	Figini et al., 1995

Appendix A (continued)

LP-608 Total organic matter	9020 ± 110	Figini et al., 1995
LP-492, Total organic matter	9180 ± 90	Figini et al., 1995
LP-305, *Succinea meridionalis*	9250 ± 140	Figini et al., 1995
LP-61O, *Succinea meridionalis*	9630 ± 110	Figini et al., 1995
Beta-84180, Gastropods	9340 ± 110	Zárate et al., 1995
AECV-1972, Gastropods	9820 ± 100	Zárate et al., 1995
Beta-79440, Gastropods	10270 ± 70	Zárate et al., 1995
Beta-84182, Gastropods	9070 ± 140	Zárate et al., 1995
Río Salado Member (upper part)		
LP-86, CaC0$_3$	3395 ± 107	Figini et al., 1985
AECV-2007, Gastropods	5720 ± 60	Zárate et al., 1995
Agua Blanca Fm.		
Lower Psephytic Member		
LP-115, *Plagiodontes patagonicus*	32300 ± 1800	Figini et al., 1985
Upper Silty–sandy Member		
SI-6449, *Lama guanicoe* (collagen)	2240 ± 55	Rabassa, 1985
AECV 882C, *Lama guanicoe* (collagen)	1960 ± 100	Deschamps and Tonni, 1992
Saavedra Fm.		
Upper Member		
LP-118, *Plagiodontes patagonicus*	9780 ± 140	Figini et al., 1985
SI-6450A, *Plagiodontes patagonicus*	5505 ± 200	Rabassa, 1985
SI-6450B, *Austroborus lutescens*	3895–1110	Rabassa, 1985
SI-6452, Charcoal	995 ± 65	Rabassa, 1985
51-6451, Human bones (collagen)	2075 ± 70	Rabassa, 1985
La Postrera Fm.		
Lower part		
LP-152, *Pseudolestodon* (collagen)	10710 ± 90	Figini et al., 1989
LP-53, *Megatherium americanum* (collagen)	8390 ± 140	Fidalgo et al., 1986
TO-1504, Bone (collagen)	8890 ± 90	Politis et al., 1983
TO-1506, Bone (collagen)	7320 ± 50	Politis et al., 1983
Upper part		
LP-189, *Lama guanicoe* (collagen)	1450 ± 50	Figini et al., 1989
Bone (collagen)	440 ± 60	Tonni, 1985
Pascua Fm.		
LP-584, Shells	>40000	Colado et al., 1995
LP-595, Shells	>40000	Colado et al., 1995
Beta-?, *Mactra isabelleana*	30190 ± 730	Cortelezzi, 1993
Destacamento Río Salado Fm. (upper part)		
LP-49, *Mactra isabelleana*	7030 ± 318	Fidalgo et al., 1981.
Las Escobas Fm.		
LP-7, Shells	5630 ± 200	Figini et al., 1978
LP-8, Shells	3050 ± 160	Figini et al., 1978
LP-9, Shells	5770 ± 170	Figini et al., 1978
LP-46, *Eubalaena* sp. (collagen)	4726 ± 219	Carbonari et al., 1980.
IVIC-188, Shells	4760 ± 120	Carbonari et al., 1980.
IVIC-268, Shells	3990 ± 70	Carbonari et al., 1980.
IVIC-269, Shells	4250 ± 70	Carbonari et al., 1980.
IVIC-266, Shells	3820 ± 80	Carbonari et al., 1980.
IVIC-270, Shells	5880 ± 80	Carbonari et al., 1980.
GrN-S 189, Shells	2990 ± 40	Carbonari et al., 1980.
GrN-5631, Shells	3530 ± 35	Carbonari et al., 1980.

Appendix A (continued)

LP-50, *Tagelus plebeius*	6150 ± 190	Fidalgo et al., 1981
LP-51, *Adelomedon* sp.	7890 ± 343	Fidalgo et al., 1981
LP-52, *Adelomedon brasiliensis*	4920 ± 216	Fidalgo et al., 1981
LP-66b, *Tagelus plebeius*	6764 ± 195	Fidalgo et al., 1981
LP-67b, *Adelomedon brasiliensis*	5934 ± 222	Fidalgo et al., 1981
LP-68b, *Mactra isabelleana*	4067 ± 224	Fidalgo et al., 1981
LP-87, *Littoridina parchappei*	6680 ± 136	Huarte et al., 1983
LP-111, *Mactra isabelleana*	3150 ± 70	Gómez et al., 1985
LP-112b, *Adelomedon brasiliensis*	3050 ± 90	Gómez et al., 1985
LP-114b, *Adelomedon brasiliensis*	7220 ± 100	Gómez et al., 1985
LP-116, *Mactra isabelleana*	3490 ± 80	Gómez et al., 1985
LP-117b, *Adelomedon brasiliensis*	3760 ± 60	Gómez et al., 1985
LP-119b, *Adelomedon brasiliensis*	4910 ± 110	Gómez et al., 1985
LP-121b, *Adelomedon brasiliensis*	3330 ± 50	Gómez et al., 1985
LP-124b, *Adelomedon brasiliensis*	6340 ± 90	Gómez et al., 1985
LP-141, *Eubalaena australis*	4030 ± 55	Carbonari et al., 1987.
LP-153, *Balaenoptera*	5535 ± 75	Carbonari et al., 1987.
LP-110, *Mactra isabelleana*	4510 ± 110	Gómez et al., 1985
LP-109, *Mactra isabelleana*	4550 ± 100	Gómez et al., 1988
LP-108, *Mactra isabelleana*	4800 ± 190	Gómez et al., 1988
LP-107, *Mactra isabelleana*	4440 ± 110	Gómez et al., 1988
LP-185, *Erodona mactroides*	6000 ± 80	Figini, 1992
LP-250, *Tagelus plebeius*	6370 ± 90	Figini, 1992
LP-256, *Tagelus plebeius*	6200 ± 90	Figini, 1992
LP-262, *Tagelus plebeius*	5500 ± 80	Figini, 1992
LP-285, *Tagelus plebeius*	5150 ± 70	Figini, 1992
LP-274, *Tagelus plebeius*	2990 ± 80	Figini, 1992
LP-297, *Ostrea equestris*	5830 ± 80	Figini, 1992
LP-577, Shells	5120 ± 70	Colado et al., 1995
LP-568, Shells	4930 ± 100	Colado et al., 1995
GrN-11564, Shells	5340 ± ?	Fasano et al., 1987
GrN-11563, Shells	6230 ± ?	Fasano et al., 1987
GrN-11562, Shells	7130 ± ?	Fasano et al., 1987
GrN-11561, Shells	7140 ± ?	Fasano et al., 1987
GrN-11560, Shells	7640 ± ?	Fasano et al., 1987

References

Aguirre, M.L., 1993. Paleobiogeography of the Holocene molluscan fauna from northeastern Buenos Aires Province, Argentina: its relation to coastal evolution and sea level changes. Palaeogeogr., Palaeoclimatol., Palaeoecol. 102, 1–26.

Aguirre, M.L., Whatley, R.C., 1995. Late Quaternary marginal marine deposits and palaeoenvironments from northeastern Buenos Aires province, Argentina: a review. Sci. Rev. 14, 223–254.

Alberdi, M.T., Menegaz, A., Prado, J.L., Tonni, E., 1989. La fauna local Quequén Salado–Indio Rico (Pleistoceno tardío) de Buenos Aires, Argentina. Aspectos paleoambientales y bioestratigráficos. Ameghiniana 25, 225–236.

Ameghino, F., 1889. Contribución al conocimiento de los mamíferos fósiles de la República Argentina. Acta Acad. Nac. Cienc. Córdoba 32, 1–1027.

Ameghino, F., 1909. Le *Diprothomo platensis*: un precurseur de l'homme du Pliocene inférieur de Buenos Aires. An. Mus. Nac. Hist. Nat. Buenos Aires 19, 107–209.

Ashworth, A., Hoganson, L., 1985. Testing the late Quaternary climatic record of southern Chile with evidence from fossil Coleoptera. Acta Geocriog. 3, 1.

Bard, E., Rostek, F., Sonzogni, C., 1997. Interhemispheric synchrony of the last deglaciation inferred from alkenone palaeothermometry. Nature 385, 707–710.

Bender, M., Sowers, T., Brook, E., 1997. Gases in ice cores. Proc. Natl. Acad. Sci. USA 94, 8343–8349.

Bonadonna, F.P., Alberdi, M.T., 1987. The N/Q boundary at 1.64 Ma? Mediterránea 6, 115–130.

Bonadonna, F.P., Leone, G., Zanchetta, G., 1995. Composición isotópica de los fósiles de gasterópodos continentales de la provincia de Buenos Aires. Indicaciones paleoclimáticas. In: Alberi, M.T., Leone, S., Tonni, E.P. (Eds.), Evolución biológica y climática de la región pampeana durante los últimos cinco millones de años. Un ensayo de correlación con el Mediterrineo occidental. Monografías CSCIC 12, Madrid, pp. 75–103.

Boninsegna, J.A., 1992. South America dendroclimatological records. In: Bradley, R.S., Jones, P.D. (Eds.), Climate since A.D. 1500. Unwin Hyman, Boston, pp. 23–45.

Broecker, W., 1996. Glacial climate in the tropics. Science 272, 1902–1904.

Budyko, M.I., Borzenkova, I., Menzhulin, LB., Shikonianov, I., 1994. Cambios antropogénicos del clima en América del Sur. Acad. Nac. Agron. Vet. Buenos Aires, p. 223.

Cabrera, A., 1957. Catálogo de los mamíferos de América del Sur. Rev. Mus. Argent. Cienc. Nat. 'B. Rivadavia', Zoología 4, 1–307.

Cabrera, A., 1960. Catálogo de los mamíferos de América del Sur. Rev. Mus. Argent. Cienc. Nat. 'B. Rivadavia', Zoología 4, 311–732.

Cabrera, A.L., 1971. Fitogeografia de la República Argentina. Bol. Soc. Argent. Bot. 14, 142.

Caldenius, C.C., 1932. Las glaciaciones cuaternarias en la Patagonia y Tierra del Fuego. Publ. Dir. Minas Geol. 95, 1–147.

Campbell, I., Mcandrews, J., 1993. Forest disequilibrium caused by rapid Little Ice Age cooling. Nature 366, 336–338.

Carbonari, J., Figini, A., Gómez, G., Huarte, R., 1980. Datación radiocarbónica de restos óseos fósiles. Res. Simp. Problem. Geol. Litoral Atl. Bon., Mar del Plata, pp. 21–34.

Carbonari, J., Figini, A., Gómez, G., Tonni, E., Fidalgo, R., 1987. Edades isotópicas de cetáceos fósiles de la Formación Las Escobas. NE de la provincia de Buenos Aires, Argentina. Actas X Congr. Geol. Argent., 3, 179–183.

Carlini, A.A., Vizcaíno, S., 1987. A new record of the armadillo *Chaetophractus vellerosus* (Gray, 1865) (Mammalia, Dasypodidae) in the Buenos Aires province of Argentina: possible causes for the disjunct distribution. Stud. Neotrop. Fauna Environ. 22, 53–56.

Cione, A.L., Tonni, E.P., 1995a. Chronostratigraphy and 'land-mammal ages' in the Cenozoic of southern South America: principles, practices, and the 'Uquian' problem. J. Paleontol. 69, 135–159.

Cione, A.L., Tonni, E.P., 1995b. Bioestratigrafía y cronología del Cenozoico superior de la región pampeana. In: Alberdi, M.T., Leone, G., Tonni, E.P. (Eds.), Evolucíon biológica y climática de la región pampeana durante los últimos cinco millones de años. Un ensayo de correlacíon con el Mediterráneo occidental. Monografías CSCIC, Madrid, pp. 47–74.

Cione, A.L., Tonni, E.P., 1995c. Los estratotipos de los pisos Montehermosense y Chapadmalalense (Plioceno) del esquema cronológico sudamericano. Ameghiniana 32, 369–374.

Clapperton, C., 1993a. Nature and environmental changes in South America at the Last Glacial Maximum. Palaeogeogr., Palaeoclimatol., Palaeoecol. 101, 189–208.

Clapperton, C., 1993b. Quaternary Geology and Geomorphology of South America. Elsevier, Amsterdam, 779 pp.

Colado, U., Figini, A., Fidalgo, R., Fucks, E., 1995. Los depósitos marinos del Cenozoico superior aflorantes en la zona comprendida entre Punta Indio y el Río Samborombón, provincia de Buenos Aires. Actas IV Jornadas Geol. Geofis. Bonaerenses 1, 151–158.

Contreras, J.R., 1973. La mastofauna de la zona de la laguna Chasicó, provincia de Buenos Aires. Physis 32, 215–219.

Cortelezzi, C., 1993. Sobre la edad de los depósitos de conchillas que afloran en las proximidades de Puente de Pascua, partido de Castelli, Pcia. de Buenos Aires. Actas XII Congr. Geol. Argent., pp. 249–251.

Crowley, T., North, G., 1991. Paleoclimatology. Oxford University Press, New York.

Daus, F., 1946. Morfologia general de las Ilanuras argentinas. GAEA 3, 115–196.

Deschamps, C.M., Tonni, E.P., 1992. Los vertebrados del Pleistoceno tardio del arroyo Napostá Grande, provincia de Buenos Aires. Aspectos paleoambientales. Ameghiniana 29, 201–210.

Dillahay, T.D., Ardilla Calderón, G., Politis, G., Moraes Coutinho, M.C., 1992. Earliest hunters and gatherers of South America. J. World Prehist. 6, 145–204.

Dillon, A., Rabassa, L., 1985. Miernbro La Chumbiada, Formación Luján (Pleistoceno, provincia de Buenos Aires): una nueva unidad estratigráfica del valle del Río Salado. Actas I Jornadas Geol. Bonaerenses, pp. 1–27.

Fasano, L., Isla, F., Mook, W., Van der Plasche, O., 1987. Máximo transgresivo postglacial de 7000 años en Quequén, Provincia de Buenos Aires. Rev. Asoc. Geol. Argent. 43, 475–477.

Feruglio, E., 1949. Descripción geológica de la Patagonia. Yacimientos Petroliferos Fiscales, Buenos Aires, 356 pp.

Fidalgo, R., 1979. Upper Pleistocene–Recent marine deposits in northeastem Buenos Aires Province (Argentina). Proc. Int. Symp. Coastal Evolution in the Quaternary, San Pablo, 1978, pp. 384–404.

Fidalgo, R., 1983. Algunas características de los sedimentos superficiales en la cuenca del Río Salado y en la Pampa ondulada. Coloq. Int. Hidrologia de Grandes Fianuras, La Plata, pp. 1–19.

Fidalgo, F., 1992. Provincia de Buenos Aires. Continental. In: Iriondo, M. (Ed.), El Holoceno en la Argentina. Cadinqua, Buenos Aires, pp. 23–38.

Fidalgo, F., Tonni, E.P., 1981. Sedimentos eólicos del Pleistoceno tardío y Reciente en el área interserrana bonaerense. Actas VIII Congr. Geol. Argent., pp. 33–39.

Fidalgo, F., Tonni, E.P., 1983. Geología y paleontología de los sedimentos encauzados del Pleistoceno tardío y Holoceno en Punta Hermengo y Arroyo Las Brusquitas (partidos de General Alvarado y Gral. Pueyrredón, provincia de Buenos Aires). Ameghiniana 20, 281–296.

Fidalgo, F., Colado, U., De Francesco, R., 1973. Sobre ingresiones marinas cuaternarias en los partidos de Castelli, Chascomús y Magdalena (Provincia de Buenos Aires). Actas V Congr. Geol. Argent., pp. 227–240.

Fidalgo, R., De Francesco, F., Pascual, R., 1975. Geología superficial de la Llanura Bonaerense. Relat. VI Congr. Geol. Argent., pp. 103–138.

Fidalgo, R., Figini, A., Gómez, G., Carbonari, J., Huarte, R., 1981. Dataciones radiocarbónicas en las Formaciones Las Escobas y Destacamento Río Salado, provincia de Buenos Aires. Actas VIII Congr. Geol. Argent., 4, 43–56.

Fidalgo, E, Meo Guzmán, L., Politis, G., Salemme, M., Tonni, E.P., 1986. Investigaciones arqueológicas en el sitio 2 de Arroyo Seco (Pdo. de Tres Arroyos–Provincia de Buenos Aires, República Argentina). In: Bryan, A.L. (Ed.). New evidence for the Pleistocene Peopling of the Americas. University of Maine Press, Portland, pp. 221–269.

Fidalgo, F., Riggi, J.C., Gentile, R., Correa, H., Porro, N., 1991. Los 'Sedimentos postpampeanos' continentales en el ámbito sur bonaerense. Rev. Asoc. Geol. Argent. 46, 239–256.

Figini, A., 1992. Edades ^{14}C de sedimentos marinos holocénicos de la provincia de Buenos Aires. Actas III Jornadas Geol. Bonaerenses, pp. 147–151.

Figini, A., Carbonari, J., 1994. Análisis de las dataciones radiocarbónicas en valvas de moluscos marinos. Actas XII Congr. Geol. Argent., II Congr. Exploración de Hidrocarburos, 2, 245–248.

Figini, A., Gómez, G., Huarte, R., 1978. Aplicación de las dataciones por el método de Carbono-14 en el campo de la Geología del Cuatemario. Res. II Reunión Infomativa del Cuatemario Bonaerense, pp. 35–40.

Figini, A., Rabassa, L, Tonni, E, Huarte, R., Gómez, O., Carbonari, J.L., Zubiaga, A., 1985. Datación radiocarbónica de gasterópodos terrestres en sedimentos del Pleistoceno superior y Holoceno del valle del Río Sauce Grande, provincia de Buenos Aires. Resumos I Jornadas Geol. Bonaerenses, pp. 131–132.

Figini, A., Rabassa, J., Tonni, E., Huarte, R., Gómez, G., Carbonari, J., Zubiaga, A., 1989. Datación radiocarbónica de gasterópodos terrestres en sedimentos del Pleistoceno superior y Holoceno del valle del Río Sauce Grande, Provincia de Buenos Aires. Actas I Jornadas Geol. Bonaerenses, 1985, pp. 809–824.

Figini, A., Fidalgo, F., Huarte, R., Carbonari, J., Gentile, R., 1995. Cronologia radiocarbónica de los sedimentos de la Formación Luján en Arroyo Tapalqué, provincia de Buenos Aires. Actas IV Jornadas Geol. Geofis. Bonaerenses 1, 119–124.

Flint, R.F., Fidalgo, F., 1964. Glacial geology of the east flank of the Argentine Andes between latitude 39º10′S and latitude 41º20′S. Bull. Geol. Soc. Am. 75, 335–352.

Flint, R.F., Fidalgo, F., 1969. Glacial drift in the Eastern Argentine Andes between latitude 41º10′S and latitude 43º10′S. Bull. Geol. Soc. Am. 80, 1043–1052.

Frenguelli, J., 1950. Rasgos generales de la morfología y geología de la provincia de Buenos Aires. LEMIT, Ser. II, La Plata.

Frenguelli, J., 1957. Neozoico. GAEA 2, 1–218.

Galliari, C.A., Berman, W., Goin, F., 1991. Mamíferos. In: López, H., Tonni, E.P. (Eds.), Situación ambiental de la provincia de Buenos Aires, A. Recursos y rasgos naturales en la evaluación ambiental. Comisión de Investigaciones Científicas de la provincia de Buenos Aires, La Plata, pp. 1–35.

Garleff, K., Reichert, T., Sage, M., Schabitz, F., Stein, B., 1994. Períodos morfodinámicos y el paleoclima en el norte de la Patagonia durante los últimos 13000 años. Rev. Mus. Hist. Nat. San Rafael 12, 179–180.

Goin, F., Carlini, A., 1989. Revisión sistemática y zoogeografla de los representantes de *Lestodelphys* (Marsupialia, Didelphidae, Marmosini) del Cenozoico, tardío de la Argentina. Resumos VI Jornadas Argent. Paleontol. Vert., San Juan, p. 101.

Gómez, G., Huarte, R., Figini, A., Carbonari, J., Zubiaga, A., Fidalgo, F., 1985. Análisis y comparación de dataciones radiocarbónicas de conchas de moluscos de la Fm Las Escobas, provincia de Buenos Aires. Resumos I Jornadas Geol. Bonaerenses, pp. 121–122.

Gómez, G., Figini, A., Fidalgo, F., 1988. Secuencia vertical de edades ^{14}C en la Formación Las Escobas en la localidad de Cerro de la Gloria, Bahía de Samborombón, prov. de Buenos Aires, Argentina. Actas II Jornadas Geol. Bonaerenses, pp. 277–281.

Gómez, G., Huarte, R., Figini, A., Carbonari, J., Zubiaga, A., Fidalgo, F., 1989. Análisis y comparación de dataciones radiocarbónicas de conchas de moluscos de la Fm Las Escobas, provincia de Buenos Aires. Actas I Jornadas Geol. Bonaerenses, pp. 623–637.

Graham, R.W., 1985. Response of mammalian communities to environmental changes during the Late Quaternary. In: Diamond, J., Case, T.J. (Eds.), Community Ecology. Harper and Row, New York, pp. 300–313.

Graham, R.W., Lundelius, E.L., Graham, M., Schroeder, E.K., Toomey III, R.S., Anderson, E., Barnosky, A.D., Burns, J.A., Churcher, C., Grayson, D., Guthrie, R.D., Harington, C.R., Jefferson, G.T., Martin, L.D., McDonald, H.G., Morlan, R.E., Semken, H.A.J., Webb, S.D., Werdelin, L., Wilson, M.C., 1996. Spatial response of mammals to Late Quaternary environmental fluctuations. Science 2772, 1601–1606.

Grill, S., 1995. Análisis palinológico de un perfil cuaternario en la cuenca del arroyo Napostá Grande (localidad: García del Río), provincia de Buenos Aires. Actas IV Jornadas Geol. Geofis. Bonaerenses, pp. 99–108.

Groeber, P., 1952. Glacial tardío y post-glacial en Patagonia. Rev. Museo Munic. Cs. Nat. Tradic. Mar del Plata 1, 79–104.

Heusser, C., 1983. Quaternary pollen record from laguna de Tagua-Tagua, Chile. Science 219, 1429–1432.

Heusser, C., Rabassa, J., 1987. Cold climatic episodes of Younger Dryas age in Tierra del Fuego. Nature 328, 609–611.

Heusser, C.J., Streeter, S., 1980. Temperature and precipitation record of the past 16,000 yr in southern Chile. Science 210, 1345–1347.

Heusser, C.J., Streeter, S., Stuiver, M., 1981. Temperature and precipitation record in southern Chile extended to 43,000 years ago. Nature 294, 65–67.

Huarte, R., Figini, A., 1988. La Plata Radiocarbon Laboratory — liquid scintillation counting. Radiocarbon 30, 347–350.

Huarte, R., Figini, A., Carbonari, J., Gómez, G., Zubiaga, A., 1983. Dataciones radiocarbónicas del sitio Punta Hermengo (Partido de General Alvarado, Provincia de Buenos Aires). Ameghiniana 20, 295–296.

Huarte, R., Carbonari, L, Tonni. E., Figini, A., 1988. Dataciones ^{14}C de restos óscos fragmentados. Metodología para su mezcla. Actas Simp. Int. Holoceno en América del Sur, Paraná, pp. 182–185.

Iglesias, A., 1981. Temperaturas. In: Chiozza, E., Figueira, R. (Eds.), Atlas Total de la República Argentina. Centro Editor de América Latina, Buenos Aires, pp. 204–208.

Iriondo, M., 1993. Geomorphology of late Quaternary of the Chaco (South America). Geomorphology 7, 289–303.

Iriondo, M., Garcia, N., 1993. Climatic variations in the Argentine plains during the last 18,000 years. Palaeogeogr., Palaeoclimatol., Palaeoecol. 101, 209–220.

Isla, I., Fasano, L., Ferrero, L., Espinosa, M., Schnack, E., 1986. Late Quaternary marine–estuarine sequences of the southeastern coast of Buenos Aires, Province, Argentina. Quat. S. Am. Antarct. Penins. 4, 137–157.

Jouzel, J., Lorius, C., Stievenard, M., 1994. Les archives glaciares de Groenland. La Recherche 261, 38–45.

Kerr, R., 1993. Even warm climates get the shivers. Science 261, 292.

Kronberg, B., Ramonell, C., Latrubesse, E., 1993. Edades C^{14} de los estadios climáticos húmedos del Holoceno de San Luis, Argentina. Resumos e Contribucoes do Simposio Internacional do Quaternário da Amazonia, Manaus, p. 153.

Ledru, M.P., 1993. Late Quaternary environmental and climate changes in central Brazil. Q. Res. 9, 90–98.

Linares, O., 1993. Mamíferos megaherbívoros en la Guayana venezolana; indicios de aridez durante el Cuaternatio tardío-Holoceno. Res. V Reunión An. Proyecto PICG-281, Climas cuaternarios de América del Sur, Santiago de Chile.

Markgraf, V., 1989. Paleoclimates in Central and South America since 18,000 BP based on pollen and lake level records. Q. Sci. Rev. 8, 1–24.

Markgraf, V., Bradbury, J.P., Fernández, J., 1986. Bajada de Pohué, Province of Neuquén, Argentina: an interstadial deposit in Northern Patagonia. Palaeogeogr., Palaeoclimatol., Palaeoecol. 56, 251–258.

Menegaz, A., Goin, F., Ortiz Jaureguizar, E., 1989. Análisis morfológico, y morfométrico multivariado de los representantes fósiles y vivientes del género *Lama* (Artiodactyla, Camelidac). Sus implicancias sistemáticas, biogeográficas, ecológicas y biocronológicas. Ameghiniana 26, 153–172.

Mörner, N., 1991. The Patagonian glaciations and the onset of general Quaternary type glaciations on the globe. Bol. Inst. Geol., Univ. Sao Paulo 8, 109–115.

Páez, M.M., Prieto, A., 1993. Paleoenvironmental reconstruction by pollen analysis from loess sequences of the southeast of Buenos Aires Province. Q. Int. 17, 21–26.

Pardiñas, U., 1995. Novedosos cricétidos (Mammalia, Rodentia) en el Holoceno de la región pampeana. Ameghiniana 32, 197–203.

Pardiñas, U., Tonni, E.P., 1996. El primer vampiro fósil de la Argentina (Mammalia, Chiroptera). Significación paleoambiental. Resumos XII Jornadas Argent. Paleontol. Vert. Santa Rosa, pp. 63–64.

Pardiñas, U.F.J., Lezcano, M.J., 1995. Cricétidos (Mammalia: Rodentia) del Pleistoceno tardío del nordeste de la provincia de Buenos Aires (Argentina). Aspectos sistemáticos y paleoambientales. Ameghiniana 32, 249–265.

Pascual, R., 1970. Evolución de comunidades, cambios faunísticos e integraciones biocenóticas de los vertebrados cenozoicos de Argentina. Actas IV Congr. Latinoamer. Zool., Caracas, pp. 991–1088.

Pascual, R., Ortega Hinojosa, E., Gondar, D., Tonni, E.P., 1965. Las edades del Cenozoico mamalífero de la Argentina, con especial atención a aquellas del Territorio Bonaerense. An. Com. Invest. Cient. Prov. Buenos Aires 6, 165–193.

Politis, G., 1984. Arqueología del área interserrana bonaerense. Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, La Plata, 540 pp.

Politis, G., Tonni, E.P., 1982. Arqueología de la Región Pampeana: el sitio 2 de Zanjón Seco (Distrito de Necochea, provincia de Buenos Aires, República Argentina). Rev. Pré-Hist. Univ. Sao Paulo 3, 109–139.

Politis, G., Tonni, E., Fidalgo, F., 1983. Cambios corológicos de algunos mamíferos en el área interserrana de la provincia de Buenos Aires durante el Holoceno. Ameghiniana 20, 72–80.

Prado, J., Goin, F., Tonni, E., 1985. *Lestodelphys halli* (Mammalia, Didelphidae) in Holocene deposits of southeastern Buenos Aires province, Argentina. Morphological and palaeoenvironmental considerations. Quat. S. Am. Antarct. Penins. 3, 93–106.

Prado, J.L., Menegaz, A., Tonni, E.P., Salemme, M., 1987. Los mamíferos de la fauna local Paso Otero (Pleistoceno tardío), provincia de Buenos Aires. Aspectos paleoambientales y bioestratigráficos. Ameghiniana 24, 217–233.

Prieto, A.R., 1996. Late Quaternary vegetation and climatic changes in the Pampa grassland of Argentina. Q. Res. 45, 73–88.

Quattrocchio, M., Borromei, A.M., Grill, S., 1995. Cambios vegetacionales y fluctuaciones paleoclimáticas durante el Pleistoceno tardío-Holoceno en el sudoeste de la provincia de Buenos Aires (Argentina). Actas VI Congr. Argent. Paleontol. Bioestrigr. Trelew, pp. 221–229.

Rabassa, J., 1985. Geología de los depósitos del Pleistoceno superior y Holoceno en las cabeceras del Río Sauce Grande, Prov. de Buenos Aires. Resumos I Jornadas Geol. Bonaerenses, Tandil, p. 9.

Rabassa, J., Clapperton, C.M., 1990. Quaternary glaciations of the southern Andes. Q. Sci. Rev. 9, 153–174.

Ramonell, C., Iriondo, M., Latrubesse, E., Kromer, R., 1993. Los climas del Cuaternatio superior en el centro-oeste de Argentina. Registro geológico de ocho estadios climáticos. Resumos e Contribuçoes do Simposio Internacional do Quaternário de Amazonia, Manaus, pp. 146–149.

Redford, K., Eisenberg, L., 1992. Mammals of the Neotropics. The Southern Cone. The University of Chicago Press, Chicago, 430 pp.

Ringuelet, R., 1955. Panorama zoogeográfico de la provincia de Buenos Aires. Notas Mus. La Plata (Zool.) 18, 1–15.

Ringuelet, R.A., 1961. Rasgos fimdamentales de la zoogeografía de la Argentina. Physis 22, 151–170.

Ritchie, J.C., Cwynar, L.C., Spear, R.W., 1983. Evidence from northwest Canada for the early Holocene Milankovich Thermal Maximum. Nature 305, 126–128.

Russo, A., Ferello, R., Chebli, G., 1979. Llanura Chaco-pampeana. Geología Regional Argentina, Acad. Nac. de Ciencias, Córdobas, pp. 139–184.

Salemme, M., 1983. Distribución de algunas especies de marmiferos en el noreste de la provincia de Buenos Aires durante el Holoceno. Ameghiniana 20, 81–94.

Salemme, M., 1987. Paleoetnozoología del sector bonaerense de la Región Pampeana, con especial atención a los mamíferos. Facultad de Ciencias Naturales y Museo, U.N. La Plata, pp. 1–267.

Salemme, M., Tonni, E.P., 1983. Paleoetnozoología de un sitio, arqueológico en la Pampa Ondulada: Sitio Río Luján (Partido de Campana, Provincia de Buenos Aires). Rel. Soc. Argent. Antropol. 15, 77–90.

Servant, M., Fontis, J.C., Rieu, M., Saliege, J.F., 1981. Phases climatiques arides holocénes dans le sud-ouest de l'Amazonie. C.R. Acad. Sci. Paris 292, 1295–1297.

Tonni, E.P., 1985. Mamíferos del Holoceno del Partido, de Lobería, Provincia de Buenos Aires. Aspectos paleoambientales y biostratigráficos del Holoceno del sector oriental de Tandilia y Area Interserrana. Ameghiniana 22, 283–288.

Tonni, E.P., 1990. Mamíferos del Holoceno, en la provincia de Buenos Aires. Paula-Coutiana, 43–21.

Tonni, E., 1992. Mamíferos y clima del Holoceno en la provincia de Buenos Aires. In: Iriondo, M. (Ed.), El Holoceno en la Argentina. Cadinqua, Buenos Aires, pp. 64–78.

Tonni, E.P., Cione, A.L., 1994. Los mamíferos y el clima en el Pleistoceno y Holoceno de la provincia de Buenos Aires. Actas Jornadas Arqueol. Interdisciplinas, Programa de Estudios Prehistóricos, Buenos Aires, pp. 127–142.

Tonni, E.P., Cione, A.L., 1995. Los mamíferos como indicadores de cambios climáticos en el Cuatemario de la región pampeana de la Argentina. In: Argollo, J., Mouguiart, P. (Eds.), Climas Cuaternarios en América del Sur. Orstom, La Paz, pp. 319–326.

Tonni, E.P., Fidalgo, F., 1978. Consideraciones sobre los cambios climáticos durante el Pleistoceno tardío – Reciente en la Provincia de Buenos Aires. Aspectos ecológicos y zoogeográficos relacionados. Ameghiniana 15, 235–253.

Tonni, E., Fidalgo, F., 1982. Geología y paleontología de los sedimentos del Pleistoceno en el área de Punta Hermengo (Miramar, provincia de Buenos Aires, República Argentina): aspectos paleoclimáticos. Ameghiniana 19, 79–108.

Tonni, E.P., Laza, J.H., 1980. Las aves de la fauna local Paso de Otero (Pleistoceno tardío) de la provincia de Buenos Aires. Su significación ecológica, climática y zoogeográfica. Ameghiniana 17, 313–322.

Tonni, E., Politis, G., 1980. La distribución del guanaco (Mammalia, Camelidae) en la provincia de Buenos Aires durante el Pleistoceno tardio y Holoceno. Los factores climáticos como causas, de su retracción. Ameghiniana 17, 53–66.

Tonni, E., Prado, J., Menegaz, A., Salemme, M., 1985. La Unidad Mamífero Lujanense. Proyección de la estratigrafia mamaliana al Cuaternario de la Región Pampeana. Ameghiniana 22, 255–261.

Tonni, E., Prado, J., Fidalgo, F., Laza, J., 1992. El Piso/Edad Montehermosense (Plioceno) y sus mamíferos. Actas III Jornadas Geol. Bonaerenses, La Plata, pp. 113–118.

Tonni, E.P., Verzi, D., Bargo, M.S., Scillato Yané, G., Pardiñas, U.F.J., 1995. Bioestratigrafía del Cenozoico superior continental en la barrancas costeras de Necochea y Miramar, provincia de Buenos Aries, República Argentina. Actas IV Jornadas Geol. Bonaerenses, Junín, pp. 63–71.

van der Hammen, T., Absy, M.L., 1994. Amazonia during the last glacial. Palaeogeogr., Palaeoclimatol., Palaeoecol. 109, 247–261.

Vizcaíno, S.F., Bargo, M., 1993. Los armadillos (Mammalia, Dasypodidae) de La Toma (Partido de Coronel Pringles) y otros sitios arqueológicos de la provincia de Buenos Aires. Consideraciones paleoambientales. Ameghiniana 30, 435–443.

Vizcaíno, S.F., Pardiñas, U., Bargo, M., 1995. Distribucion de los armadillos (Mammalia, Dasypodidae) en la región pampeana (República Argentina) durante el Holoceno. Interpretación paleoambiental. Mastozool. Neotrop. 2, 149–166.

Wirrman, D., Oliveira de Almeida, L., 1987. Low Holocene level (7,700 to 3,650 years ago) of lake Titicaca (Bolivia). Palaeogeogr., Palaeoclimatol., Palaeoecol. 59, 315–323.

Zárate, M., Flegenheimer, N., 1991. Geoarchaeology of the Cerro La China locality (Buenos Aires, Argentina): site 2 and site 3. Geoarchaeology 6, 273–294.

Zárate, M., Espinosa, M., Ferrero, L., 1995. La Horqueta II, río Quequén Grande: Ambientes sedimentarios de la transición Pleistoceno–Holoceno. Actas IV Jornadas Geol. Geofis. Bonaerenses, Junín, pp. 195–204.

Zunino, G.E., Vaccaro, O.B., Canevari, M., Gardner, A., 1995. Taxonomy of the genus *Lycalopex* (Carnivora: Canidae) in Argentina. Proc. Biol. Soc. Washington 108, 729–747.